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THE NEW ENGLAND ENERGY POLICY ALTERNATIVES STUDY

FINAL REPORT
FOR THE DEPARTMENT OF ENERGY
AND THE NEW ENGLAND STATES

The Commonwealth of Massachusetts
Michael S. Dukakis, Governor

Massachusetts Energy Office
Henry Lee, Director

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NEW ENGLAND ENERGY POLICY ALTERNATIVES STUDY

The Economic Impacts of Energy Conservation and Alternative Electric Generation Scenarios, 1975-1985

A Report Done for the Department of Energy and the New England States

by

THE MASSACHUSETTS ENERGY OFFICE

Henry Lee
Director

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Henry Lee
Director

NEW ENGLAND ENERGY POLICY ALTERNATIVES ADVISORY COMMITTEE MEMBERS

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Governor's Council on Energy
New Hampshire

Joseph Belanger
Connecticut Energy Office
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Economics Dept.
University of Maine

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MIT
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State Energy Office
Montpelier, Vt.

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Dept. of Community Affairs
One Ashburton Place
Boston

Dennis Heffley
Dept. of Economics
University of Connecticut

Marc Hoffman
Massachusetts Energy Facilities
Siting Council
Formerly with the
Connecticut Dept. of Planning
and Energy Policy

Dante Ionata
State Energy Office
Providence, R.I.

Fred Kaen
Whittemore School of
Business & Economics
University of New Hampshire

Linda Mansfield
Dept. of Energy
Boston

Barbara Boynton
Dept. of Energy
Boston

Victoria Potter
State Energy Office
Rhode Island

Robert Radcliffe
Office of Energy Resources
Maine

Marc Schupak
Dept. of Economics
Brown University

William Shipman
Economics Dept.
Bowdoin College

New England Energy Policy Alternatives Study

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Preface

In the world of economics, the economist is often guilty of speaking in an abbreviated manner to a narrow group - more often than not, to other economists. As a result, the message to those outside this fraternity of experts is often unclear. Moreover, rightly or wrongly, the economist is almost never responsible for implementing policy based upon his/her research. As a result, the task of interpreting the economist's work and formulating policy is often left to those not extensively trained in economics. While recognizing that those trained in the discipline will evaluate the rigor of the work, this study is aimed at those policy makers whose decisions will collectively shape our world for many years to come.

Because the ultimate users of this analysis are most likely generalists, it is important that our message not be obscured (at least consciously) by an overly technical presentation of the material.

Although it is difficult to escape the necessity of technical terminology, particularly with a "first of its kind" economic model, we have, nevertheless, attempted to keep the presentation of the final report clear and to the point. Of course, that endeavor is never antithetical to good research whether it be in economics or other fields. Therefore, in the report which follows, the technical material has been kept to a minimum and its presentation saved for appendices.

This study has two very significant sets of implications. The

first set is primarily of interest to policy makers. These are the actual results of various hypothetical policy simulations. Equally significant from a methodological point of view is that the model is a first-of-a-kind attempt to better understand the interaction between energy and the economic behavior of various sectors of our society.

Overview

Working under the auspices of the six New England governors and with close working support from their respective energy staffs, the Massachusetts Energy Office has recently completed Phase I of a macroeconomic study of the region's energy policy options over the next decade.

The report which follows is divided into two sections. In Section I, the New England Macroeconomic Model (NEME) is constructed using U.S. Department of Energy Project Independence Evaluation System (PIES) economic behavioral assumptions for the nation as a whole. The NEME model (see p. 50) fits New England energy, labor and production into a PIES framework and evaluates 16 possible future energy scenarios. Included in these simulations are conservation, Outer Continental Shelf (OCS) development and nuclear and coal plant construction simulations.

Section I of this report then sets forth the study's purpose, methodology and findings with respect to these 16 scenarios using DOE/PIES behavioral assumptions.

In Section II of this report, the DOE/PIES behavioral assumptions are critically examined and new regional-specific behavioral assumptions are developed for the residential, commercial and industrial sectors in order to account for changes in the behavior of these sectors stemming from the 1973 "energy crisis". It must be noted that the inclusion of these new assumptions amounts to the construction of

a new NEME model in Section II. The DOE/PIES behavioral assumptions used in Section I are based upon a period from 1960 to 1972 and do not account for changes in behavior after 1973. In addition, in Section II, simulations incorporating these new regional-specific behavioral parameters are described and the new results are reported. The simulations presented in Section II represent (1) different economic and energy scenarios than presented in Section I, (2) provide a basis for projections of New England's energy needs and their effect on economic outcomes, and (3) present projections of alternative technological and policy options.

Specifically, the study in both sections estimates the economic effects of a range of possible energy events using a "what if?" approach. It seeks to answer questions such as, what would be the condition of the New England economy if, for example, nuclear power plant construction were limited to only one new plant before 1985?

For Section I, the 16 simulations consider the economic effects of the following energy events:

1) Conservation in the residential, commercial and industrial sectors. In addition, a comprehensive conservation scenario combining all three sectors is undertaken.

2) Exploration and development of potential New England Outer Continental Shelf oil and natural gas reserves.

3) The number of nuclear power plants proposed for construction is reduced from five new plants assumed for 1985 (assumed in the Base Case)

to only one new plant between 1976 and 1985.

4) Direct economic impacts of coal plant construction.

For Section II , a new model is developed and fifteen alternative energy scenario simulations are undertaken. These simulations are broken down into four categories:

1) A new "Base" case is prepared using the new behavioral parameters.

2) An investigation into the consequences of alternative projections of economic conditions and alternative assumptions for aggregate economic growth.

3) The third set of simulations examine various energy price projections for the region.

4) In the final set of simulations, alternative technological assumptions are imposed on the base projections. These include an investigation of more extensive use of coal by the manufacturing sector, use of solar energy by the residential and commercial sectors, and the adoption of cogeneration technologies by manufacturing industries.

The purpose of using the two models constructed in this study (1) NEME, using DOE/PIES national behavioral assumptions, and (2) NEME using New England specific behavioral assumptions - is straightforward and seeks to respond to such questions as: "Do existing energy strategies and conservation programs respond strongly enough to the region's long-run energy problems, and are they targeted on the most productive areas?"

This study is responsive to that question and and examination of the economic impacts of various energy alternatives for the period 1975-1985 is undertaken using both models.

The present study was funded by the Department of Energy (formerly FEA) in October, 1976. Research began in December, 1976.

FINDINGS

As indicated in the Overview of this study, two distinct models are constructed: (1) NEME using DOE/PIES behavioral parameters, and (2) NEME using regional specific behavioral parameters. The results of NEME model runs using the DOE/PIES parameters are set forth in Section I. These results indicate overall that conservation, at least for the next decade, is the region's best strategy for reducing oil imports, reducing overall energy costs, creating new jobs, and increasing gross regional production.

In Section II, the NEME model incorporating regional behavioral parameters reinforces the conclusions reached in Section I. However, due to the more refined nature of the NEME model used in Section II, more accurate projections of possible energy policy outcomes are made available. Moreover, as a result of the new behavioral estimates, significantly higher levels of employment, gross regional production and energy savings due to reduced power plant construction and increased conservation efforts are forecast. As a result, the conclusions and policy implications set forth in Section I are strengthened and overall improvements in the model's estimates are made.

A few of the study's major findings are set forth below:

1) Economically efficient and attainable conservation in the residential, commercial and industrial sectors can create

as many as 50,000 new jobs, increase production by $2 billion and reduce energy costs to the region by $1.4 billion annually by 1985.

Our conservation simulations suggest that if advantage is taken of existing technological opportunities, these substantial levels of energy conservation and economic benefits can be realized. Technologically feasible and economically efficient measures can reduce energy usage to a level 18.3% below our Section II Base projections by 1985.

2) Our simulation results show that price signals which reflect the real scarcity of energy are an important means of achieving an efficient allocation of this resource. However, price scenarios we examined, including one with quite high "real" energy prices, yielded energy savings of no more than 8.6% over our Base Case by 1985. Our results indicate that raising energy prices above the marginal cost of supply in order to induce a 30% technically feasible conservation level imposes a high economic cost. As a result, other means of tapping this latent conservation potential, including regulatory activities, should be investigated.

3) For every one percent increase in Gross Regional Production (GRP) per capita, energy demand will increase by 0.5%. This significant finding contradicts the widely held belief that the energy and production relationship is one-to-one.

4) Electric generation planning. The results of the low nuclear case mentioned in Section I of this study indicate that future electric prices are likely to be sensitive to the timing of

new generation capacity. Coordination of forecasting with probable conservation and construction plans can result in lower electricity prices. For example, the effect of not building or delaying an additional nuclear plant in the region by 1985, together with economically efficient and attainable conservation in all sectors of the economy, can lead to lower electricity prices and even greater economic benefits than set forth above in item 1.

5) Solar, cogeneration and other alternative generation options will have little macroeconomic impact on the region's economy by 1985. However, the importance of alternative technologies post-1985 is thought to be substantially greater and more work is needed on ways to encourage and make these relatively marginal economic ventures more productive.

6) Energy demand in New England will increase at 1.55% annual growth rate from 1980 to 1985. Electricity demand will grow at a rate of 3.13% annually to 1980, and 2.74% annually from 1980 to 1985.

7) On the other hand, petroleum demand will increase 1.2% per year to 1980 and about 0.7% per year from 1980 to 1985. These growth rates reflect approximately 20% conservation in transportation, 10% conservation in the manufacturing sector, and 3% conservation for services and residential demand in 1985 over per unit energy uses in 1974. Higher energy prices assumed for these projections bring about the observed conservation, but even with this conservation , <u>real</u> energy costs per unit of <u>real</u> production rise 3.2% by 1980 and 2.1% by 1985.

8) DOE/PIES simulation indicates that the introduction of Outer Continental Shelf (OCS) oil supplies will not significantly impact New England's oil prices. Preliminary analyses indicate that a major natural gas find could have a greater impact on the New England energy situation.

SUMMARY

SECTION I

1.0 The Base Case

Before proceeding further, it is important that we all have the same starting point. The starting point for evaluating the impact of various energy events on the New England economy in Section I is the Base Case. For purposes of this study, the Base Case can be said to be a composite picture of the New England economy at a single point in time. A 1974 base year was selected and the model was calibrated with 1974 data which was constantly refined as better information became available. This allowed us to extrapolate a 1985 Base Case for purposes of comparison.

Hence, the "what if" scenarios that follow have a common ground - the fact that they each "take-off" from the base case for each year from 1978 to 1985. The significance of the various scenarios is therefore the extent to which they differ from the Base Case projections.

Two kinds of economic effects are estimated in the study: direct and indirect. The first refers to jobs and investments directly associated with an event. The second refers to the more significant measures of economic activity, indicated by gross regional product, the number of jobs in the region, and changes in the cost of living. Indirect effects are associated with changes in regional spending patterns, energy budgets, and product prices.

The year 1985 was chosen as the point to which we would measure economic impacts. To simplify the analysis, we assumed that a particular energy event was completed by 1985. The direct effects of an energy event are not included in the estimated impacts for 1985, since they occur at an earlier time. These direct effects are given separately in Table A. A complete discussion of these effects is set forth in the text of the study.

1.1 Case Overview

All simulations testing potential energy events are modifications of the 1985 Base Case. The direct impacts of off-shore oil development (see Appendix I), changes in nuclear construction plans, and conservation investments are each considered in terms of the extent to which primary demand effects differ from the Base Case for a particular year. Conservation programs are also considered in cases where economic demand is held constant, and the efficiency of energy use is then explicitly modified from the 1974 standard. Costs of these modifications are included to reflect price impacts accurately. The electricity price

Table A: Summary of Direct Impacts*

Event	(Investment)** (Efficiency) ($/Av. yrly 10^6 Btu's Available)	Direct Impacts: Investment (bil $)	Direct Impacts: Jobs (person) (years)	Duration in Years	Average Yearly: Jobs	Average Yearly: Incomes (mil $)
Outer Continental Shelf Development						
High	-0-	3.5	84,000	30	2,800	45.
Med.	8.7	.967	18,025	25	721	11.2
Lo	-0-	.012	665	15	44	.73
Coal (one plant)	21.1	.800	3,271	5	654	16.7
Nuclear (one plant)	21.1	1.00	5,368	5	809	20.7
Commercial						
COM 5-30	6.33	2.564	104,000	3	34,667	405.
COM 12-30	13.93	5.643	228,800	6	38,133	446.
Residential						
RES 20	3.3	.903	29,516	3	9,839	193.
RES 30	3.3	1.243	38,180	6	6,363	125.
Industrial	9.2	1.392	-0-	-0-	-0-	-0-
Comprehensive Conservation	9.4	7.938	258,316	3/6	44,496	639.

NOTE: OCS, Coal and Nuclear plants are in nominal dollars.

* See Appendix I, Construction and Development Impacts, for further details.

** Net Present value discounted at 5% per year.

mechanism of the model is used to simulate changes in power plant construction.

The Base Case uses energy supply prices projected by the DOE/PIES model, and economic growth for New England is based on information provided by Data Resources, Inc. and the Massachusetts Econometric Model (Treyz et al., 1977). Energy is used in the same manner (efficiency) as in 1974, except that users can substitute among fuels based on prices.

2.0 Conservation Cases

Conservation cases were simulated individually by sector, along with one comprehensive conservation scenario. Price-induced conservation is also considered.

2.1 Price-Induced Conservation (PRICCON)

The study estimates the effects of price-induced conservation by allowing energy use per unit to adjust to rising prices. The parameters used to control this adjustment reflect national behavioral responses to energy price changes in the 1960 to 1972 period. The costs of these changes are uncertain. Thus, price and economic effects indicated are for the lowest cost assumptions, and may be optimistic.

Table B

SUMMARY OF SIGNIFICANT CASES

	Real Average Price Index**	Production Index **	Total Employment (millions)	Energy Use-Trillion Btu's Utility *	Non-Utility
1974	1	100.00	5.148	582	2206
1985 Base	1.1	142.48	6.235	800.2	3014
Commercial Conservation	1.094	142.74	6.242	652.5	2759
Residential Conservation	1.090	143.45	6.271	640.9	2813
Industrial Conservation	1.098	142.49	6.233	724.6	2939
Comprehensive Conservation	1.087	143.29	6.260	456.1	2529
Reduced Nuclear Construction	1.097	142.52	6.237	1039.	2986
Reduced Nuclear with Conservation	1.084	143.33	6.264	693.4	2947

* Utility energy use treats nuclear use as kWh output; thus, comparisons between fossil generation and nuclear generation are inaccurate for total utility energy use.

** Production Index - 1 point = $1.1 billion.

2.2 Commercial Conservation (COM F-20, COM F-30, and COM 5-30)

This study simulates several conservation cases to represent differing levels of conservation in the commercial sector, and different assumptions about the cost of achieving those improvements. Our study of commercial capital stock suggest a fairly wide range of potential costs and savings. However, the impact of new building standards seems particularly promising in terms of conservation potential and costs.

2.3 COM F-20, COM F-30

Free no-cost savings of 20% and 30% respectively. These scenarios bracket a range of savings which could be achieved at essentially no net cost (payback under 1 year). These reductions correspond to per-unit savings of 40% in new buildings, as in ASHRAE 90-75 (new buildings are those built after 1978 for COM F-30, and new buildings built after 1980 for COM F-20), and 15%-20% in old buildings (COM F-20 and COM F-30 respectively).

2.4 COM 5-30

This case reduced total energy use per unit, and implements new buildings standards as in COM F-30. However, in this option, investments are required to achieve 20% conservation in old buildings. Assuming old buildings comprise 75% of the energy use, these investments have a payback period of from two to four years, with a 10% to 20% real interest rate, or cost of money.

2.5 Commercial Conservation: Discussion

In order to test the sensitivity of the results of the above cases, other commercial conservation simulations were considered. Energy use reductions of 10%, 20% and 30% per unit were simulated. One cost assumption is that these conservation levels are achieved at no additional net cost to the firm. The other is that an investment achieving a 10% reduction will pay itself back in two years; increased investments to reach a 20% reduction, in four years; and additional investments to reach a 30% reduction will pay back in six years. These cost assumptions were arrived at after meetings with conservation experts on the average cost of conservation improvements requiring alterations/additions to capital stock.[1] These costs reflect an assumption that "easy" improvements are embodied in the 1974 case. As such, these cost estimates are probably somewhat high.

3.0 Industrial Conservation (Ind)

For the industrial sector, one level of conservation was simulated, based on Department of Energy studies of economically achievable reductions in energy use. These studies indicate an average per-unit reduction of 16% for regional manufacturing industries.

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1 Energy conservation experts consulted include Xenergy Inc., 14 Hartwell Ave., Lexington, Mass. and Vanderweil Engineers, Inc., 52 Chauncy St., Boston.

3.1 IND

This case considers efficiency improvements which are economically viable, as the study defines economic viability. The average investment in this case has a four-year payback, with a 12% real capital cost.

4.0 Residential Conservation (RES 20, RES 30)

For the residential sector, two levels of conservation were simulated, corresponding to Improvements I and II studied in the DOE Residential Energy Forecasting model (REFORM). These were 20% reductions in the DOE residential energy use (RES 20) and 30% reduction in residential energy use (RES 30). The annual costs of these improvements were based on the REFORM estimates of total costs, assuming a 5% real capital cost (corresponding to a 10% to 11% nominal cost). Estimates of economic impact for these cases are also based on sensitivity analysis for changes in disposable income.

5.0 Comprehensive Conservation (CONT)

This case considers the effects for a comprehensive conservation approach in the three major sectors. It is a composite of conservation cases considered above. Thus, energy savings from capital investments, similar to IND, RES 20, and COM 12 - 30 (12% real interest, 30% conservation) are contained in this simulation. It should be noted that the COM 12 - 30 simulation, which is the same as COM 5-30 except that 12% real interest is assumed, probably overstates the cost of reducing commercial energy use.

6.0 Alternative Electric Generation Scenarios: (LO NUK, LO NUK C LO NUK CON, Coal)

Alternative electric scenarios consider the effects of coal conversion and reduced nuclear plant construction. The effects of low nuclear construction with two different conservation scenarios are also considered.

6.1 LO NUK

Only one new nuclear plant is constructed before 1985. Appropriate changes are made to capital cost components of electrical charges.

6.2 LO NUK C

One new nuclear plant with price induced conservation. This case is thus comparable to PRICCON.

6.3 LO NUK CON:

Combines low nuclear construction with conservation measures as in CONT. Thus, to some extent this case represents the substitution of conservation investments for electric generation investments.

6.4 COAL:

Coal conversion of two oil-fired plants, as ordered by the Department of Energy. Capital cost of conversion is added to fixed charge. Conservation induced by price increases resulting from the coal conversion is included. Thus, this case is more directly comparable to (PRICCON).

7.0 Discussion of Findings

7.1 Commercial Conservation

Reductions in the use of energy per unit of service by 30% (of the energy assumed necessary in the Base Case) can be achieved in the commercial sector through modest cost energy conservation. Such conservation can occur through the adoption of a new, thermal-efficient building code for new buildings (such as ASHRAE 90-75) and through 20% reductions in energy consumption in existing buildings. Conversations with professionals working in building conservation indicate that a 20% reduction in energy use for

existing buildings can be achieved through low-cost operating improvements.[2] As the summary table (Table B) shows, this 30% reduction could reduce total regional energy use by 10% or 403 trillion BTU's , or roughly 68 million barrels of oil. Prices in the commercial sector would fall, as a result of this conservation, by nearly 1%, reducing the cost of living by 0.6%. The gross regional product is increased by this conservation by 589 million (1974 dollars), adding 7,300 additional jobs to the region.

7.2 Residential Conservation

Based on our study of the residential housing stock, we conclude that as much as 80% of that housing stock has "inadequate" ceiling insulation, storm windows, and weatherstripping. We estimate the cost of achieving a minimum attic insulation level of R-19 (6 inches of fiberglass), storm windows and weatherstripping to be \$1.156 billion (1978 dollars). On a micro-economic level, these would be very good investments, with better than a two-year payback. The economic impacts to the region are also significant. Comparing the results of such action to the 1985 Base Case, residential energy use would be reduced by about 20%, and total regional energy use by 7%. Demand for goods and services increases as fuel cost savings are spent in the region. Production thus increases by 0.45%, or \$830 million, and employment by 0.32% or 19,800 jobs.

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[2] Ibid.

If we add floor or basement insulation to the above measures, as well as general improvements in the efficiency of home appliances, residential energy use could be reduced by 30%, compared to the 1985 Base Case. These improvements would cost approximately $1.6 billion in 1978 dollars. They would achieve a reduction in total New England energy use of 10% or 383 10^{12} BTU's. The cost of living would be reduced by nearly 1%, and regional production would be increased by nearly $1.2 billion (1974 dollars), creating 28,700 new jobs.

7.3 Manufacturing/Industrial Conservation

Since we do not have information on potential industrial capital improvements and costs, we were forced to make certain assumptions regarding such costs and savings, as indicated by the Department of Energy's study of conservation in manufacturing industries.[3] This simulation indicated that conservation could reduce manufacturing energy consumption by 16%, with total regional energy use therefore reduced by 4%. The price of manufactured goods would decrease by 0.7%, and overall prices would be cut by 0.2%.

7.4 Reduced Power Plant Construction

Our Base Case assumes the construction of five new nuclear plants between now and 1985, with one plant added between 1974 and 1978. The Low Nuclear Case reduces that to one additional new plant on line

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3 Voluntary Conservation Targets

in early 1983. It should be noted that these cases were selected prior to modification of new plant construction schedules by various New England utilities. Changes in electric demand forecasts have modified that construction schedule, so that current construction plans are identical to this Low Nuclear Case. The lower nuclear use is replaced by greater reliance on existing oil generating capacity. Despite the increased fuel costs, electric prices would decrease 7% in 1985, compared to the five new nuclear plant Base Case. This reduction is due primarily to the reduction in excess capacity.[4] Such a situation does put the region in a more vulnerable position in case of another OPEC oil embargo. We have not estimated the value of this risk, but it will probably not be greater than the value of decreased electric prices for the region.

Decreased electric prices reduce the cost of living by 0.3% and increase production employment by 0.03%. These findings should not be interpreted to mean that additional baseload power generation is not economic for New England. In fact, our preliminary findings suggest that the economics of baseload power plant construction will change radically in the period from 1985 to 1995. However, as noted, the study is limited to the specific period 1975 to 1985, and therefore does not take into account certain possibilities which might occur after that date.

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[4] Excess capacity is the proportion of a utility's generating capacity over and above industry standards for peak load requirements and reserve capacity. The FPC recommends a 20%-over-peak-load reserve requirement.

8.0 Policy Implications

The economic benefits of conservation indicated above reflect the difference between how the economy could develop with certain government programs, and how it would develop without those programs. In any case, there will be some price-induced conservation, whatever the government does. The energy savings from such price-induced conservation, using Department of Energy estimates, are 4.8% reduction in industrial energy use, 4.6% reduction in commercial energy use, and 6.4% reduction in residential energy use from 1985 Base Case projections. The total regional conservation derived from DOE/PIES price-induced estimates is about 10.7%.[5] These figures indicate that existing market forces will encourage some conservation. However, additional savings could be achieved if government programs were to stimulate the adoption of conservation measures evaluated in this study. These additional savings would have a significant positive economic effect.

The estimated economic benefits of conservation can be used to justify the cost of government programs. The results of the reduced nuclear construction option indicate a need for improved planning in building new facilities.

Several assumptions are necessary in order to estimate what program costs for conservation might be justified. First, we must establish the duration of the estimated economic impacts. For example, we assume these benefits will last twenty years. Secondly, the bene-

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[5] The Department of Energy parameters "predict" significant reductions in transportation energy use as well. For example, commercial transportation falls about 30%, and resident transportation decreases by almost 21%.

fits <u>due to government action</u> must be clearly determined. Our estimates of price-induced responses to energy costs allow us to gauge how much savings would occur without governmental programs.[6]

If government implemented programs to stimulate conservation, we estimate the region would receive the following annual economic benefits: $156 million in annual benefits from savings to the commercial sector, and $550 million in annual benefits from savings to the residential sector. Using the above assumptions, we estimate the present value of these benefits to be $1.94 billion for the commercial sector and $6.85 billion for the residential sector (given a 5% real discount rate using 1974 dollars). These benefits in the residential sector are 7.5 times larger than the estimated cost of insulating homes in the region. On this basis, conservation program costs of $1.9 billion for commercial and $6.85 billion for the residential sector would be cost-justified in New England.

The reader should note that, as in any modelling or forecasting work, there is a considerable amount of uncertainty involved in modelling the interaction between energy and economic activity. We have made every effort to ensure that the actual benefits will not be less than those estimated in the model. We have thus minimized the possibility that programs might not achieve a suitable return. Factors which might indicate lower benefits include:

1. Optimistic economic forecasts may overstate energy use, and thus the potential for reduction.

2. While the 1985 Base Case "permits" substitution away from higher-priced fuels, the model does not provide for substitution of less energy-intensive materials in the production process.

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6 Preliminary results from our estimates of price-induced conservation indicate that price responses may be larger than those estimated here. (See Section II, Appendix 5).

In other words, direct energy use can change. However, "invested" energy use may not change. Thus, the impact of rising energy prices may be somewhat overstated in the Base Case. However, there are also countervailing factors which indicate the benefit could be higher than predicted:

1. The current structure of the model underestimates the income effects of conservation investments. In some situations, the model loses some of the energy cost savings of conservation. The effect is small, but significant, since the conservation impacts are a small percentage change in total economic activity. Some adjustments have been made, but in all cases income of 0.2% to 0.3% of total disposable income is left out. Adding this income back into the model would increase yearly production by about 0.14% or $250 million.

2. There are probably income multiplier effects between two to three times the direct income effects calculated. These are due to the diversion of energy expenditures which left the region to expenditures within the region. Thus, the benefits estimated may be as little as one-third of the actual impact.[7]

3. The direct impacts of investments are not added to macroeconomic impacts. These effects may last for five or six years, and are often as large as the macroeconomic impacts. Considerable uncertainty exists in determining whether these investments would be net additions to the regional economy.

Considering these factors, the Massachsuetts Energy Office believes there is a good possibility that the benefits of investment would be at least as large as estimated, and very probably larger.

The following policies seen justified by the economic benefits estimated in the study:

1. <u>Commercial Conservation</u>: Energy efficiency building standards for new construction, and information programs for existing buildings. There is a good potential for conservation in the com-

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[7] For a complete discussion of income acocunting problems, see Appendix I.

mercial sector, at virtually no net cost to the region's economy. Standards for new construction would ensure that future building stock will be less sensitive to price increases.

2. <u>Manufacturing/Industrial Conservation</u>: Conservation in the manufacturing sector has benefits which extend beyond the region. Information programs would probably be effective. Further steps could be justified at the federal level.

3. <u>Residential Conservation</u>: Conservation in the residential sector would have significant economic benefits. Public financing of residential conservation should seriously be investigated, since the benefits are estimated to be 7.5 times larger than the cost of insulating New England homes. (See RES 20 case).

4. <u>Electric Generation Planning</u>: The results of the low nuclear cases mentioned above indicate that future electric prices are likely to be sensitive to the timing of new generation capacity. Hence, the coordination of forecasting with probable conservation and construction plans can result in lower electric prices.

SUMMARY

SECTION II

9.0 Energy Scenario Simulations

In Section I of the NEEPA project we developed the New England Macroeconomic model (NEME) which was then used to examine the consequences of alternative energy supply and macroeconomic demand scenarios for energy demand and economic outcomes in the New England region.

Following the completion of Section I, we estimated several new macroeconomic behavioral parameters, incorporated them into the model, and examined the consequences of energy scenarios similar to those in Section I. In addition, in this section of the report, alternative economic, energy supply, technological and energy demand scenarios are considered. These simulations, together with those in Section I, represent alternative economic and energy scenarios, and so provide a basis for projection of (1) New England's energy needs, (2) the effects of these demands on economic outcomes (unemployment, price effects of energy costs, production, and income levels), and (3) the consequences of alternative technological and policy options.

Fifteen simulations, or alternative scenarios, which examine four categories of possibilities, are described. The first set of simulations will be used to prepare a base projection case. These will include a simple extrapolation of 1974 energy use patterns to 1980 and 1985, followed by examination of exogenously-forced conservation. The information from these scenarios is then used with new

behavior parameters, describing the response of sectoral energy use patterns to changes in sectoral energy prices to determine a base projection case. These new behavioral parameters were estimated by Abbott and Lutostanski and are presented in Appendix IV. In order to investigate the consequences of the behavioral parameters set forth in Appendix IV, the base projection was also estimated using the parameters and functional form used in the U.S. Department of Energy's PIES model (Project Independence Evaluation System, Documentation) and previously used in NEME. The second category of simulations investigates the consequences of alternative projections of economic conditions and particularly alternative assumptions on aggregate economic growth. These scenarios examine more pessimistic and more optimistic assumptions than those utilized on the base case, as estimated by independent economic forecasters. The third set of simulations examine alternative projections of energy prices to the region. These will measure the New England economy's response to various world energy supply situations as well as the possibility of higher energy prices resulting from government policies. Higher price scenarios will be simulated using both the new behavioral parameters presented in Appendix IV and the DOE/PIES parameters again to investigate the consequences of these alternative behavioral assumptions. In the final set of simulations, alternative technological assumptions will be imposed on the base projections. These will include investigation of more extensive use of coal by the manufacturing sector, use of solar energy by residential and commercial users, and adoption of cogeneration technologies by manufacturing industries.

10.0 Section II Base Case

The base case erected in Section I using DOE/PIES parameters is an extrapolation of 1974 energy use patterns through 1985. As set forth in Appendix IV, we developed an energy use adjustment mechanism and additional behavioral assumptions. These have been incorporated into the NEME model and a new Base Case has been constructed for use in Section II.

In the new Base Case, six simulations are examined: (1) EXTRAP is a simple extrapolation of 1974 energy use patterns to 1980 and 1985 economic activity levels projected independently of the model; (2)-(4) are three conservation simulations (CON20, CON30 and CON30NS) which are believed to be efficient attainable conservation levels; (5) a BASE projection is then constructed using behavioral parameters developed and presented in Appendix IV and represents basic projections of economic growth, behavioral response and energy demand in response to DOE-projected energy prices; and (6) FEABS, which is identical to the BASE case with the exception that by using the DOE/PIES model parameters rather than our new independent behavioral parameters as developed in Appendix IV, the consequences of alternative energy demand assumptions can be more rigorously evaluated.

10.1 A Simple Extrapolation ("EXTRAP") (Appendix V, A-2)

This simulation is comparable to the Section I base case and holds energy use per unit of output fixed at 1974 levels while economic output and area income continue to expand. National forecasts show that a real per annum growth rate of 3.746% is appropriate for the United States economy for the years 1974 through 1980. Beyond 1980, it is probable that the national output will grow at 3.65% per year. Projected New England growth rates are somewhat lower. This slower growth is caused by less population growth and a slower recovery from the recent recession. New nuclear construction is

limited to one new plant.

10.2 20% Conservation ("CON20") Appendix V, A-3)

The hidden capacity for energy conservation and the associated increase in capital costs have been the focus of numerous engineering studies - it is possible to reduce energy demand if the capital stock is upgraded. This "conservation" scenario incorporates Massachusetts Energy Office estimates of conservation and annualized capital costs. In essence, it states that many conservation investments which could achieve quick payback (less than 2 years) are available. Here, these investments are undertaken and the costs are levelized over the life of the capital equipment - which is exceedingly long. It is believed that the cost reductions will foster economic expansion.

10.3 30% Conservation ("CON30")(Appendix V, A-4)

Similarly, in this simulation, more conservation investments which could achieve longer paybacks are undertaken. These higher investment costs are levelized over the extremely long life of the capital equipment. It is believed that cost reductions will be passed along to the consumer and foster economic expansion. Again, Massachusetts Energy Office estimates of capital costs are incorporated.

10.4 30% Conservation: No Seabrook ("CON30NS") (Appendix V, A-5)

The conservation and capital cost assumptions of the previous

simulation are maintained. However, dwindling electricity demand as a result of heavy conservation efforts has made the planned addition of one nuclear plant seem unnecessary. This base capacity and its capital charge are eliminated in this simulation. The changes are outlined in Appendices 5, A-1 and A-5.

10.5 Base Case ("BASE") (Appendix V, A-6)

The macroeconomic growth projections of the extrapolations and the conservation scenarios are still maintained. However, the only exogenously specified conservation corresponds to the federally mandated increase in the fuel efficiency of the residential transportation fleet. All other energy use adjustments (and additional adjustments in residential transportation) are price-induced. This simulation outlines the response that might be expected from "normal behavioral parameters".

This simulation uses the price elasticity and lagged response mechanisms estimated by the authors (Abbott and Lutostanski, 1978, Appendix IV) for use in this model for manufacturing, services, and residential energy services. Energy use of each fuel by each of those sectors separately responds to changes in the price of that fuel and the price of available substitutes. Transportation models utilized DOE/PIES parameters.

10.6 FEA Base Case ("FEABS")(Appendix V, A-7)

The only differences between the Section II "Base" simulation and this

simulation occur as a result of using a different mechanism to adjust energy use to prices. This simulation uses the "two-step" model of energy demand determination (DOE/PIES), its own price elasticities, its own lagged adjustment mechanism, and a greater time trend in electricity use. The basic macroeconomic and energy price projections are maintained.

11.0 Alternative Economic Growth Projections

Two alternative assumptions on the likely economic future of the New England region are considered in this case. The simulation scenario, named HIGRO, assumes that real growth in gross regional product will be 3.95% per year to 1980 and 3.35% per year from 1980 to 1985, in place of the assumptions used in both EXTRAP and Section II BASE that GRP will increase at 3.5% per year from 1974 to 1985. The LOGRO scenario assumes that growth in real GRP is 3.33% per year to 1980 and 2.97% per year from 1980 to 1985.

11.1 High Economic Growth ("HIGRO") (Appendix V, A-8)

In this version of the macroeconomic inputs, more optimistic economic growth is foreseen through 1980. Real growth for New England increases through 1980, then slacks off through 1985. Still, real area income is substantially (2.1%) higher in 1985 than in the Base Case.

For each one percent change in the growth rate in area income, roughly one-third corresponds to a change in productivity, another third to a change in the labor force, and the remaining third to a change in the unemployment situation.

11.2 Low Economic Growth ("LOGRO") (Appendix V, A-9)

Again, the Abbott-Lutostanski parameters outlined in Appendix 4 control energy use adjustment, and the only change in real energy prices will be produced endogenously in the electric sector. The Exogenous macroeconomic inputs are more pessimistic. Regional economic growth is slowed only slightly through 1980, but then drops off markedly through 1985. By 1985, real area income has been reduced 3.8% below the base projection.

12.0 Alternatives Price Projections

Among the most uncertain assumptions used in our projections are the energy price estimates. These inputs are subject to domestic public policy initiatives, supply constraints and volatile OPEC (Organization of Petroleum Exporting Countries) cartel behavior.

In this set of simulations four price scenarios are considered. One assumes higher energy prices (HIPRI), another lower energy prices (LOPRI), the third assumes a "crisis scenario", and the fourth examines a high price scenario, using DOE/PIES behavioral assumptions (FEAHP).

12.1 High Energy Prices ("HIPRI") (Appendix V, A-10 or A-1)

This scenario considers changes in energy use that could be expected to occur in response to higher real energy prices. The simulation considers higher oil, nuclear, and coal costs and higher electrical generation, transmission and distribution equipment costs.

12.2 FEA High Price ("FEAHP") (Appendix V, A-10 or A-1)

In this scenario the same high energy prices and increased electrical sector capital costs are maintained. Regional macroeconomic activity grows at the basic rates. However, the two-step energy demand model (DOE/PIES) now gives its estimates of the price induced changes in energy demand.

12.3 High Price, Low Path ("HIPLOP") (Appendix V, A-10 or A-1)

In this case, energy prices and nuclear plant capital costs reach their 1985 levels as previously outlined. However real energy prices remain constant at 1978 levels through 1980. This means that "low" prices are used for 1980 and the high prices are used for 1985.

12.4 Low Energy Prices ("LOPRI") (Appendix V, A-10 or A-1)

What would be the energy use pattern in 1985 if real energy prices remained constant at 1978 levels through 1980, and then rolled part of the way back to 1974 levels? This scenario keynotes the disruptive economic effects of rising real energy prices in New England.

13.0 Alternative Technologies

Recent events in energy markets have also brought attention to new technological alternatives which could enhance energy coservation in New England, or reduce dependence on petroleum as an energy source. Three such alternatives are cogeneration of electricity by the manufacturing and service sectors, modeled in the simulation labeled COGEN; additional use of coal by the manufacturing sector, called COAL; and the use of solar energy for space and water heating by both residential users and the service sector, called SOLAR. For each of these cases, energy uses have been altered to reflect the potential utilization of these options with other energy uses per unit, frozen at projected BASE levels. Simulation results will be used to examine

the potential energy demand and economic effects of adoption of these technologies. Since it is unlikely that any of these alternatives will be adopted to a great degree by 1980, only simulation results for 1985 have been produced.

13.1 Cogeneration ("COGEN") (Appendix V,A-11)

In this simulation, the manufacturing and commercial services sector install 1679 megawatts of electricity-generating equipment by 1985. With this electric equipment on site, transmission losses are reduced and the steam by-product can also be better utilized. The manufacturing sector will generate 34.06 trillion BTU's of electricity using this technology. Half of this electricity can be used directly on-site; the other half must be resold to the electric utility for redistribution. The commercial services sector will generate only 6.06 trillion BTU's of electricity using this technology; 60% of this must be sold to the electric utility for redistribution.

13.2 Industrial Use of Coal ("COAL") (Appendix V, p.41)

Before the imposition of higher standards for air quality, the industrial sector in New England burned coal as a major form of fossil fuel energy. This scenario examines the return to coal consumption levels of the mid-1960's.

13.3 Solar Heating ("SOLAR") (Appendix V, A-12)

Data for this simulation were provided by the Solar Action Office of the Commonwealth of Massachusetts. Passive solar systems are to be incorporated to reduce space heating demands for the

commercial services and residential sectors. These passive solar systems are to be designed into new construction and are assumed to have little cost. Hot water heating, on the other hand, has an associated capital cost of $2500 (1978 dollars) for a system that reduced annual energy demand by 11 million BTU's. These capital costs are repaid at an 8% annual nominal rate in the residential sector and at a 10% annual nominal rate in the commercial sector.

Reductions in energy demand for hot water heating are assumed to be savings in electricity use. Reductions in demand for space heating are shared in proportion to the Base Case use of electricity, distillate, and residual (see Appendix 5, A-12).

14.0 Simulation Results

Table 1 sets forth comparison of selected results of Section II simulations. For example, the most likely case in both 1980 and 1985 (assuming no governmental intervention or market disruptions such as resumption of mid-East hostilities) is the Base Case.

For comparison purposes the other 14 cases for the most part are comparable to the Base Case. As can be seen in Table 1, the CON30 case would reduce the unemployment rate projected for 1980 in the Base Case by 6% and for 1985 by 13% The Real Price Index would be 0.6% below expected 1980 levels, and 1.3% below expected Base Case 1985 levels. Physical production by 1980

Section II

Table 1

Selected Energy Scenario Simulation Comparisons

	BASE		EXTRAP		CON20		CON30		CON3ONS
	1980	1985	1980	1985	1980	1985	1980	1985	1985
Unemployment %+	5.9%	5.18%	6.358	5.807	5.70	4.67	5.583	4.438	4.383
Real Price Index	1.047	1.086	1.054	1.098	1.043	1.077	1.041	1.072	1.071
Production*	153.7	175.8	152.7	174.0	154.2	177.1	154.5	177.8	177.9
Electricity (¢/kWh/1974)	3.64	3.67	3.659	3.632	3.73	3.77	3.765	3.851	3.714
Energy Cost**									
Res.	2692	2955	2712	3027	2492	2524	2370	2239	2207
Ser.	2356	2781	2402	2857	2201	2369	2092	2098	2071
Man.	1333	1473	1423	1661	1334	1444	1318	1411	1384

	Historical	FEABS		HIGRO		LOGRO		HIPRI		FEAHP	
	1974	1980	1985	1980	1985	1980	1985	1980	1985	1980	1985
Unemployment %+	6.63%	6.080	5.368	5.321	4.814	6.01	5.332	6.036	5.825	6.229	6.187
Real Price Index	1.000	1.048	1.088	1.052	1.090	1.046	1.079	1.049	1.098	1.051	1.102
Production*	131.1	153.4	175.3	158.1	178.6	153.3	170.7	153.4	174.0	153.0	173.2
Electricity (¢/kWh/1974)	3.632	3.065	3.578	3.626	3.612	3.641	3.627	3.750	4.301	3.710	4.221
Energy Cost **											
Res.	2467	2704	3044	2710	2959	2690	2935	2731	3282	2270	3469
Ser.	1909	2509	2966	2433	2831	2350	2688	2411	3153	2654	3346
Man.	1045	1450	1714	1365	1493	1330	1435	1355	1600	1483	1948

Section II

Table 1 (continued)

Selected Energy Scenario Simulation Comparisons

	BASE		HIPLOP	LOPRI		COGEN	COAL	SOLAR
	1980	1985	1985	1980	1985	1985	1985	1985
Unemployment %+	5.9%	5.18%	5.837	5.838	4.369	5.144	5.120	5.105
Real Price Index	1.047	1.086	1.098	1.046	1.080	1.086	1.086	1.085
Production*	153.7	175.8	174.0	153.8	176.7	175.8	175.8	175.9
Electricity (¢/kWh/1974)	3.64	3.62	4.295	3.585	3.450	3.617	3.615	3.631
Energy Cost**								
Res.	2962	2955	3300	2674	2864	2950	2955	2920
Ser.	2356	2781	3154	2334	2648	2736	2780	2747
Man.	1333	1473	1612	1329	1465	1310	1469	1476

* Billions of 1974 dollars

++ Millions of 1974 dollars

\+ Labor Force: 1980 = 6.104 million
1985 = 6.617 million

would increase $800 million and for 1985, $2 billion. Under the CON30 simulation, electricity prices would rise by one mill/kWh by 1980 and more than two mills/kWh by 1985.

As can be seen from Table 1, energy costs to the residential sector (not including transportation) decrease from the Base Case $322 million by 1980 and by over $700 million by 1985. These savings are the result of improved residential insulation and other technological improvements.

Similar comparisons for the other 13 scenarios are made in Table 1.

15.0 Conclusions and Policy Implications

The Section II energy scenario simulations of the New England economy and its likely energy use have provided a number of insights into the problems with, and potential for, energy policy in the region. In addition, they provide a strong basis for projecting New England's energy requirements for 1980 and 1985.

15.1 Base Projections

The basic projections suggest that energy demand in New England will increase at a 1.5% annual growth from 1980 to 1985. Electricity demand will grow at a rate of 3.13% annually to 1980, and 2.74% annually from 1980 to 1985. On the other hand, petroleum demand, excluding gasoline, will increase 1.2% per year to 1980 and 0.7% per year from 1980 to 1985. These growth rates reflect approximately 20% conservation in transportation, 10% conservation by the manufacturing sector, and 3% conservation for services and residential energy demand in 1985 over per-unit energy uses in 1974. The higher energy prices assumed for these projections bring about the observed conservation; but they also cause total energy costs and hence directly cause real sectoral prices, to rise 0.5% by 1980 and 0.6% by 1985. However, even with this conservation, real energy costs per unit of real production rise 3.2% by 1980 and 2.1% by 1985. Moreover, the real price indicies (inclusive of higher labor costs) rise 4.7% by 1980 and 8.6% by 1985.

15.2 Alternative Economic Projections

Examination of alternative economic projections also suggested that alternative projections can lead to somewhat different energy demands. Our results indicate that for every one percent increase in projected Gross Regional Product, energy demand will increase by about 0.5%. Increases in petroleum and electricity demand are slightly greater than that figure. This result is largely due to the fact that income elasticities of demand for residential transportation and residential energy services are less than that of overall economic growth.

We also found that the choice of a model specification of energy demand behavior can substantially alter projections. The behavioral parameters estimated in Appendix 4 of this project yield considerably more optimistic projections than do the parameters of the DOE/PIES "two-step" model set forth in Appendix 3. In addition, the unexpectedly high energy costs resulting from the DOE/PIES parameters are additional evidence that our regional parameter estimates, and particularly our projections of exogenous electricity demand increases, are a more reasonable approximation of New England behaviors.

15.3 Conservation

The conservation simulations suggest that apparent technological opportunities exist to obtain substantially greater levels

of energy conservation. They indicate that technologically feasible and economically efficient measures can reduce energy demand to a level 18.3% below our basic projections by 1985. Petroleum demand could be reduced by about 15%, as well. Such conservation would also be of substantial benefit to the economy. Sectoral prices could be as much as 1.4% lower by 1985, with unemployment rates up to 0.67 points lower. These come about as a result of the real cost savings due to energy conservation.

15.4 Alternative Energy Price Projections

Unfortunately, higher energy prices which are within a reasonable upper limit are unlikely to elicit this conservation. The price scenarios examined, including one with quite high energy prices, yield energy savings of no more than 8.6%, in total, by 1985. This raises two questions which remain to be addressed. The first is, how can the technological opportunities which appear to exist be encouraged by policy? Price signals cannot achieve these conservation goals alone, and come with a high economic cost, so additional means of eliciting such behaviors must be discovered. The second question is, are the cost assumptions made for these technological opportunities realistic? Any time such apparently profitable opportunities are rejected, one should ask himself if some hidden costs are missing. Our results, however, suggest that pursuing these conservation opportunities may be the best opportunity for regional energy policy makers.

The alternative price scenarios also indicate that higher energy prices impose a substantial economic cost to the New England region. Since virtually all primary energy sources are imported, higher energy prices raise real costs to the region without imparting any economic benefits. If higher energy prices are the result of federal policies to induce conservation and reduce dependence on foreign oil, these economic costs must be weighed against the benefit of energy conservation achieved. Ways of bringing about that conservation which avoid the use of potentially damaging higher prices or which use taxes whose proceeds remain within the New England region are clearly superior. Those higher energy prices may also be intended to prepare the regional economy for an impending "crisis" of sudden and substantial price increases, but the economic benefits of such preparations which are price-induced are small in the medium- to long-run, especially when compared to the costs of higher energy prices. That is not to say that energy conservation as a preparation for such a crisis is undesirable, but rather that price signals are not the most cost-effective means of eliciting such preparations.

15.5 Alternative Technologies

Technological options, including increased utilization of solar energy, increased coal usage by the manufacturing sector, and cogeneration of electricity and useful "waste heat" were also explored.

These options had little macroeconomic impact, but could bring about net energy savings. Additional solar use could reduce regional petroleum demand by 1.65%, and additional coal use could substitute coal for 0.9% of that demand. The cogeneration alternative, according to current assumptions, would reduce coal utilization by the region through reduced electricity demand, and would make conversion of two oil-fired electric generating plants unnecessary. A more reasonable alternative than our current assumptions for cogeneration might be the elimination of one planned nuclear power plant, rather than idling residual-fired capacity and foregoing coal conversions, but that is if cogeneration activities are implemented. A question which remains is how these relatively marginal economic ventures could be encouraged, so that the obtainable energy savings could be achieved.

The simulation results and our work in preparing inputs highlighted the importance of planning in the electric sector as well. Both planning and bringing on-line sufficient capacity without providing excessive capacity, and properly controlling costs, are important issues. What happens in other sectors of the economy can significantly impact electricity prices and demand, so coordinated planning is desirable. This is another area in which regional energy policy makers should be involved.

The details of the individual simulations suggest a number of other interesting problems and issues. The most significant result of this work, however, is that policies which depend on energy price manipulations are less likely to be productive than policies which affect

energy conservation behavior directly. Also, the microeconomics of technological and energy conservation alternatives deserve further careful examination, as many questions are raised when one examines the consequences of our current assumptions.

Final Report

Section I: The Economic Impacts of Conservation and Alternative Electric Generation Scenarios, 1975-1985

16.0 Background: The Need for the Present Study

In 1975 a group of New England Energy Policy Analysts began to consider four basic energy policy alternatives for the region. The primary analytic tool used in this effort was the former Federal Energy Administration's "Project Independence Evaluation System" (PIES) computer model. The PIES model is an integrated energy demand and supply forecasting system. The demand side is primarily econometric in nature and the supply side is a combination of simulation and linear programming techniques. (See Part B, New England Energy Situation and Alternatives for 1985, a Department of Energy, Region I, publication.)

However, no conclusions regarding the regional economic impacts of energy alternatives were drawn in that study since the PIES model is primarily a tool for forecasting national energy supply and demand interactions. The study did indicate that conservation was a desirable way to reduce energy consumption.

Through the Energy Policy and Conservation Act, federal funds have been made available to the states for conservation programs. Policy makers and program planners consider these programs vital to improving our long-run energy situation. These beliefs are based on expected depletion of energy resources and rising prices for existing supplies. Still undetermined is whether existing energy programs are strong enough to cope with the long-run energy problem, and whether existing strategies focus on the most productive areas.

An examination of the economic impacts of various energy alternatives is necessary. Policy analysts working with the PIES forecasting model recognized this and requested funding from the Federal Energy Administration (now the Department of Energy) to estimate the economic impacts of energy alternatives considered in PIES.

16.1 Purpose of Study

The purpose of this study is straightforward and seeks to compile information relevant to the energy policy and conservation questions discussed above. As mentioned, work with the PIES model had provided some answers to the "what if a particular event were to happen?" question. We had not yet developed a way to estimate the relationship between energy events and regional economy. For policy purposes, the "what if" question required an estimate of such economic measures as Gross Regional Product, employment, and cost of living. The primary task of this study, then, was to develop a consistent methodology for estimating these impacts and to apply this methodology to energy events considered by the PIES study team. This study attempts to build upon the earlier regional efforts to develop a comprehensive base of information. The same cases, or energy events, used in PIES are used in this study. The study examines the economic impacts of conservation in the three major sectors (residential, commercial and industrial); alternative electric generation scenarios; and development of Outer Continental Shelf oil and natural gas.

Our first task was to collect, and put into a consistent

framework, volumes of existing information. Within that framework we developed estimates of economic impacts associated with these varying alternatives. Since the alternatives considered are those of the 1975 study, we used only the PIES model to provide energy supply and price projections for fuels in the region. (Details are provided in Appendix III.) Because our purpose was to gather information, we used existing studies of energy uses and costs, and adapted them for our use wherever possible. To improve the accuracy of our economic estimates we used the most recent information available.[1]

Among the cases simulated in the PIES model for 1985 were the following:

Base Case. Demand reduction is limited to price-induced conservation. In the electric utility sector, this case assumes that no more than five new nuclear plants, and no new coal plants, may be built. The case also assumes that only one 250,000 bbl/day refinery may be constructed. Solar use in this case will result in a saving of 24,000 barrels of oil. The equivalent of 20 trillion Btu's of solid waste is utilized to generate electricity in this case.

Conservation Case. It is assumed in this scenario that concerted action on the part of New England states can achieve energy demand reductions from the Base Case levels of 12 percent to 20 percent. This is specified by sector and by fuel type. The case also includes a program of load management. Solar energy achieves 1.4 million barrels of oil savings in 1985 and solid waste utilization is equivalent to the base case.

Low Nuclear Case. This case differs from the base case in that new nuclear capacity is limited to one new plant after 1978, or two new plants after 1974. Since one new plant (Millstone) did come on line between 1974 and 1978, this case changed between the time the report was drafted and the date of its completion.

In this study we break down the conservation cases by Sector. The analysis of new coal facilities done under the original PIES effort

is set forth in Section II of this report.

We retained three important conclusions of the PIES report as our primary assumptions in quantifying economic impacts of alternative energy. These are: (1) conservation programs have virtually no impact on New England's oil and natural gas prices; (2) potential oil and natural gas supplies from the Outer Continental Shelf, with or without a New England refinery (see Appendix I), will have no impact on New England's oil and natural gas prices; and (3) conservation programs will affect New England's electric rates. Our efforts to estimate economic impacts have included attempts to model the impacts of conservation on electric rates.

16.2 Methodology

Our first task was to develop an analytic method to reflect accurately the role of energy use and energy prices in the New England economy. Energy directly and/or indirectly affects virtually all goods and services produced in the region. The quantity and type of energy needed to produce a particular good or service varies greatly. The quantity and cost of energy to New England's economy is determined by:

1. The amount of goods/services demanded, and
2. The nature of the capital stock used to produce them.

To represent this view of energy use in the New England

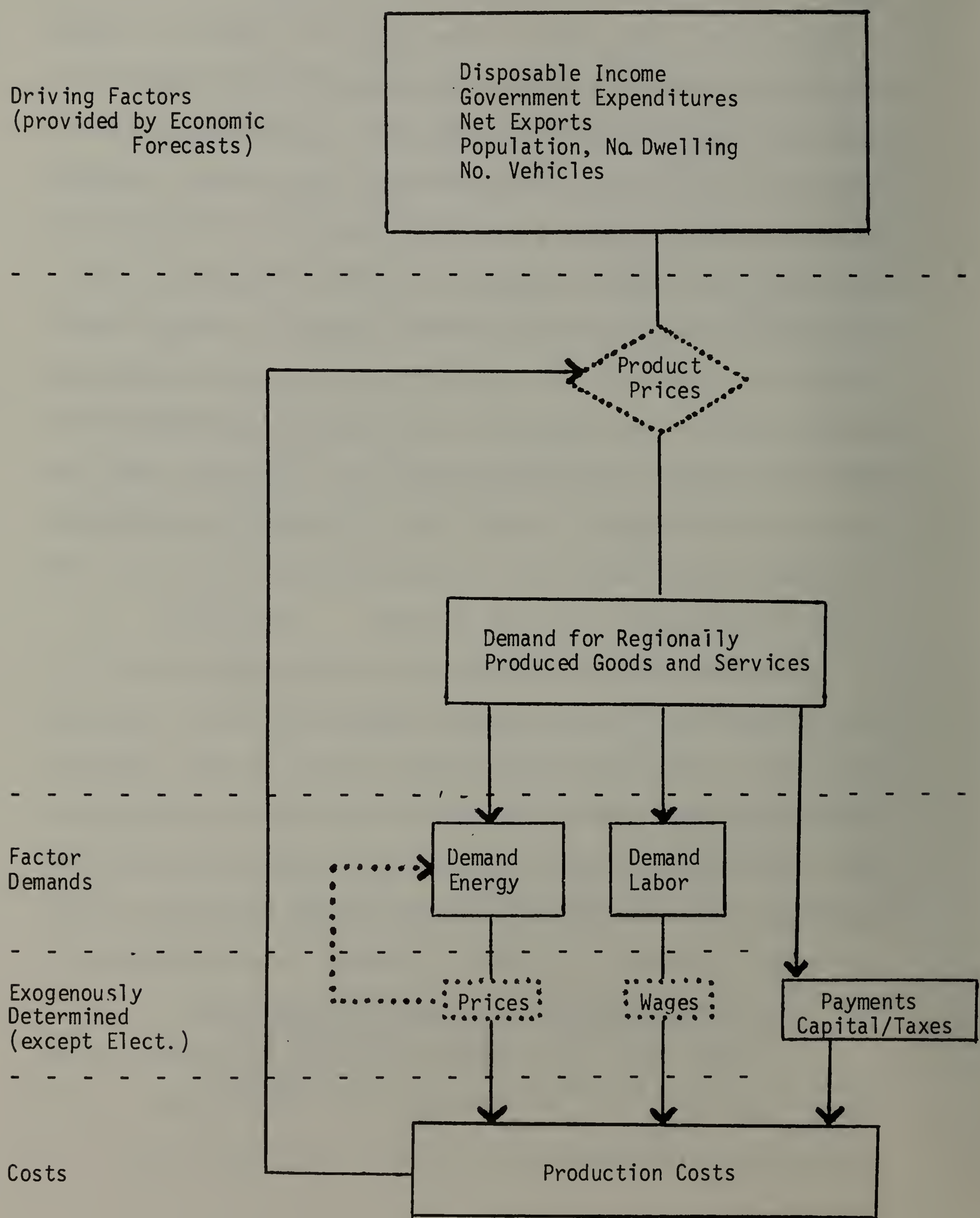
economy, we developed the New England Macro-economic Energy Model (NEME). A description of this model is found in Appendix III. NEME is an "input-output" model, which places particular emphasis on energy use. The model determines the quantity and type of energy required for each unit of goods or services produced for a given historical year. The model also determines the quantities of other goods or services required to produce each particular good or service. For purposes of this model, the region's economy is divided into seven sectors, classified by type of goods or services produced and type of energy consumed. For example, the electricity sector both consumes and produces energy. (See Exhibit A.) We therefore can examine how the demand for energy is affected by both the demand for goods and services, and by changes in capital stock. The model also provides an accurate method of estimating the effect changing prices have on the prices of New England's goods and services.

The historical year selected for designing the model was 1974, the most recent year for which complete data were available. Thus, the nature of the energy-using capital stock existing in 1974 is embodied in the model. Since the cost of OPEC oil increased significantly in 1974, we assume that the model already takes into account a significant portion of "easy" behavioral adjustments to reduce energy (e.g., lower thermostats and turning off lights). The model includes the effect of 1974 energy prices on goods and services in the base year.

The NEME model, using DOE/PIES behavioral assumptions, serves then as a consistent tool for estimating the economic impacts of energy alternatives in New England and allows to be consistent with our

SCHEMATIC DIAGRAM

NEW ENGLAND MACRO ECONOMIC ENERGY MODEL



(For details on model, see Appendix III)

EXHIBIT A

Producing Sectors - Aggregated

(i) = 1 - Agriculture, Mining, and Construction
2 - Manufacturing
3 - Commercial Transportation
4 - Services
5 - Residential Transportation Energy
6 - Residential Energy Services
7 - Electricity

Producing Sectors - Disaggregated

(j) =	Sector	sic #
1	Food	20
2	Tobacco	21
3	Textiles	22
4	Apparel	23
5	Lumber	24
6	Furniture	25
7	Paper	26
8	Printing	27
9	Chemical	28
10	Petroleum and Coal	29
11	Rubber and Plastics	30
12	Leather	31
13	Stone and Glass	32
14	Primary Metals	33
15	Fabricated Metals	34
16	Machinery	35
17	Electrical Equipment	36
18	Transportation Equip.	37
19	Instruments	38
20	Other Manufacturing	39
21	Agriculture	
22	Mining	
23	Construction	
24	Commercial Transportation	
25	Services	
26	Residential Transportation Energy	
27	Residential Energy Services	
28	Electricity	

Primary Products - Energy Forms and Labor

(k) = 1 - Electricity
2 - Nuclear
3 - Natural Gas
4 - LPG
5 - Gasoline
6 - Kerosene
7 - Distillate
8 - Residual
9 - Coal
10 - Exotic Energy Forms (Hydro power, solar, etc.)
11 - Labor

examination of cases in the PIES model. The year chosen for which the various cases would be simulated is 1985.

We developed the necessary inputs to simulate various cases by drawing upon existing studies, and on models of the cases and sectors in question. A Base Case was prepared to correspond to recent demand projections of DOE's PIES model. Recent PIES demand forecasts were significantly different from the results of the 1976 study. This was necessary since PIES-projected energy prices were generally being used in the model. There are minor differences between PIES-forecasted energy demands and NEME forecasts (within three percent of total energy demand). These differences are primarily due to two factors:

1. Different energy uses assumed in particular sectors for the initial year of each forecast, and

2. The PIES forecast implies a slightly faster growing manufacturing sector than the NEME model. (It should be noted that economic activity forecast in the NEME model is derived from more general economic forecasting models.)

The impacts of conservation were analyzed separately for each sector. This enables us to refer to the specific capital stock in each sector as we project they will be for 1985 and to estimate the cost of modifying that stock to make it energy-efficient. Thus, energy conservation is specifically simulated as using less energy per unit of output than was true for 1974. The cost of modifying the capital cost is incorporated into the prices charged for each sector.

Estimating the cost of investing in new capital stock, and estimating the cost of improving energy efficiency, is difficult to do

accurately. Weatherization costs in the residential sector were estimated by using data on the existing capital stock and directly estimating the quantity of insulation required to improve heating efficiency. (See Appendix I for a data summary.)

In the service sector, building energy uses (e.g., heating, air conditioning, and lighting) account for the majority of energy use. Several independent studies and conversations with firms in the business of making these buildings more energy-efficient were used as data for calculating the cost of improving regional commercial building stock. Three levels of conservation and three cost levels were selected to simulate commercial conservation in the NEME model. These were chosen to correspond to the variety of estimates available. The cost estimates selected generally correspond to the cost of capital improvements for commercial buildings. Some of the cost estimates given in this study for commercial conservation may overstate the costs of achieving energy-efficient building operation. Many existing buildings could reduce energy consumption by up to 15% with simple, low- or no-cost changes in operating procedures.

Estimating the costs of energy conservation in the manufacturing sector was virtually impossible. The New England Energy Policy Alternatives sponsored study of the <u>Economic Impact of Energy Policies on the Wood Furniture and Metalworking Equipment Industries in New England</u> (Appendix II) provides some insight into the forces affecting manufacturers' investment decisions regarding energy conservation. We used "rule of thumb" costs and levels of conservation to simulate conservation in this sector for the NEME model. These were based on

DOE studies of "economical" conservation measures attainable in major manufacturing groups.[2]

Summaries of the methodologies used to estimate direct impacts and inputs required for simulation in the NEME model follow. More detailed discussions are available in the technical appendices to this report.

17.0 Direct Impacts

There are two kinds of economic impacts - direct and general. While direct impacts do not present a complete picture of the economic impacts of a particular energy event, policy makers and program planners should be aware of them. New England's labor pool is finite. It has only a certain amount of skilled labor to draw upon for a given energy event. The region must also bid against other regions for products, equipment or materials required for a particular event.

The energy events considered here all require some capital investments. The conservation options require changes in energy using equipment, modifications to existing buildings and/or construction of energy-efficient new buildings. The alternative electric generation scenarios require changes in new plant investments, or investments to modify existing oil-fired facilities.

Such changes in capital investment will have direct impacts on

jobs and income in the region. However, the net economic impact depends upon the kind of investment and whether it displaces other investments in the economy. If labor skills or other resources required for a particular event would otherwise be used for some other purpose, no net, or additional jobs, are created.

The impacts shown (Table I) are those job and income effects directly associated with particular investment projects; conservation investments in the commercial, residential, and manufacturing sectors, and construction of nuclear power plants. A reliable method for calculating the net impacts of these investments has not been found. Investments which completely displace other investments would have no net impact, while investments which use previously unused resources could have net impacts up to three times larger than the direct impacts shown.[3]

Table I summarizes the direct impact of estimated investments associated with the energy options considered in this study. Required investments were calculated separately for each sector, as presented in Appendix I. To determine the total impact of a particular scenario, one could add the direct impacts shown in Table I to the macro-eonomic impacts associated with a particular scenario in Tables V-XV. However, such an estimate would be reliable only if there were unused labor resources appropriate for the particular event. It has proven difficult to get this information.

TABLE I: Summary of Direct Impacts*

Event	Investment Efficiency ($/Av. yrly 10^6 BTU's available)	Direct Impacts: Investment (bil $)	Direct Impacts: Jobs (person years)	Duration in Years	Average Yearly: Jobs	Average Yearly: Incomes (mil $)
Outer Continental Shelf Development						
High	-0-	3.5	84,000	30	2,800	45.
Med	8.7	.967	18,025	25	721	11.2
No	-0-	.001	665	15	44	.73
Coal (one plant)	21.1	.800	3,271	5	654	1.67
Nuclear (one plant)	21.1	1.00	4,043	5	809	2.07
Commercial						
Com 5-30	6.33	2.565	104,000	3	34,667	.405
Com 12-30	13.93	5.643	228,800	6	38,133	.446
Residential						
Res 20	3.3	.903	29,516	3	9,839	193.
Res 30	3.3	1.243	38,180	6	6,363	125.
Industrial	9.2	1.392	-0-	-0-	-0-	-0-
Comprehensive Conservation	9.4	7.938	258,316	3/6	44,496	639.

Note: OCS, Coal, and Nuclear plants are in nominal dollars.
*See Appendix I, Construction and Development Impacts, for further details.

The average yearly jobs and income impacts are relatively large when compared with the macroeconomic impacts. However, due to the uncertainty surrounding the net impact of these investments, whether the investment is a gross addition or displaces other investments, the direct investment impacts have not been added to the macroeconomic impacts. This method tends to underestimate the total economic benefits attributed to a given scenario.

Since various energy events may compete for the same limited resources in the New England economy, we must consider the efficiency with which these resources are used. For policy purposes, the relevant measure is the amount of energy each alternative investment provides.

In order to compare varying energy events, we define investment efficiency measurement as the cost in dollars of making a million Btu's available each year.

The investment efficiency column of Table 1 (dollars per yearly million Btu's made available) provides a very rough measure of the energy impact of these investments. Of course, the different investments will affect particular fuels differently. Nevertheless, the relative attractiveness of energy conservation investments can be clearly seen.

A 20 percent reduction in energy use for the commercial sector can be achieved with virtually no net investment. Thus, investment efficiencies approaching \$0 per million (10^6) Btu are feasible. Therefore, the investment cost of achieving 30 percent conservation, as in the commercial sector (case COM 5-30) i.e., 30 percent energy reduction at five percent cost of money), may be overstated by a factor of two.

This may well mean that a 30 percent cut in commercial energy consumption is competitive with residential conservation investment. On the other hand, the sharp rise in investment efficiency indicates a rapid increase in the marginal costs of increasing the level of conservation from 20 percent to 30 percent.

The COM 12-30 case (30 percent energy reduction at 12 percent the cost of money) indicates the impacts of the most extreme cost assumption. The investment efficiency is reduced significantly.

Residential conservation investments are very cost-effective, as indicated by their superior (lower) investment efficiency. The fact that the investment efficiency of the RES 20 (20 percent reduction) and RES 30 (30 percent reduction) cases are comparable indicates additional potential for residential energy savings.

The direct impacts in the comprehensive conservation case are a composite of conservation investments in the COM 12-30 case, the RES 20 case, and the IND case (industrial conservation). Thus, the investment efficiency in this case is a worse case measure ($9.40 per yearly millions of Btu's made available). The actual investment efficiency of conservation would probably be higher. Nevertheless, the investment efficiency of Outer Continental Shelf development is in the same range, indicating the benefits to such efforts.

The worst investment efficiencies indicated are for new electric plants. It should be noted, however, that electricity is a premium energy form, with superior end use efficiencies. Furthermore, this investment efficiency should be relatively stable, while conservation

investment efficiencies will increase as low-cost conservation efforts will be used up and the marginal cost of conservation will increase. In addition, the cost of money (interest rates) for nuclear plant investment is unlikely to rise very rapidly. We can infer from this that there is a stable nuclear market.

18.0 General Economic Impacts

The following section presents the results of our calculations of general or indirect economic impacts in the year 1985. These are estimates of changes in energy use and macroeconomic factors associated with the various energy scenarios considered. They do not include simulation for the Outer Continental Shelf development, since the impacts of this event seem to be confined to the direct investment effects outlined in the previous section.[4] (See Appendix I.) Past and current PIES simulations indicate sufficient energy supplies to meet the projected 1985 demands in all cases.

The Base Case assumes the construction of five nuclear power plants by 1985. Recent decisions by electric utilities make this assumption unrealistic. However, there was no time to recalculate the Base in light of these decisions. The inclusion of these plants in the Base Case in no way alters the conclusions regarding general economic impacts stemming from the energy conservation scenarios.

18.1 Base Case

The Base Case assumes that energy used in 1985 is used in the same manner as in 1974. This case is a simple extrapolation of 1974 energy use patterns. We selected economic projections for 1985 to be

compatible with the PIES model energy supply and price forecasts. The energy prices we use also come from PIES, except for electricity and natural gas. (These projections are given in Tables II and III.) Six nuclear plants are added to 1974 generation capacity. The one exception to the 1974 energy use patterns is electricity. Additions in electric-using equipment are required to correspond with PIES electice use forecasts in the manufacturing and commercial sectors.

The Section I Base Case indicates that energy use in New England will grow at a rate of 2.86% per year from 1974 to 1985, increasing by 36.32% or 1016 trillion Btu's in that time (Table V, V(a)).[5] Disposable income increases by 3.5% per year. Growth rates for the major energy forms range from 4.77% for electricity to 1.99% for natural gas. This is largely because a two percent per year exogenous increase in electric use by the manufacturing and commercial sectors is assumed to be consistent with PIES forecasts. It was our belief that these figures are an optimistic forecast and the results presented in Section II bear out this belief. The actual growth projections in Section II turned out to be lower. Again, this Base Case does not represent the projections of the Massachusetts Energy Office or any other state agency. It is solely an extrapolation from federal PIES calculations and is utilized to give the study a base from which to measure economic change.

Real energy prices increase approximately 17% (Table IV), causing real price increases in all sectors, and an average real price or cost of living increase for the New England economy of 10.02% in 1985. This is led by a 13% increase (cumulative) in energy costs for transportation in the residential sector and an 18.5% increase for other energy uses by households. The smallest price increase, 7.9%, is in the commercial sector. This means

the energy problems New England faces will likely result in a continued shift from a production economy to a service economy.

19.0 Conservation

Conservation is the cornerstone of the region's energy policy. As this study shows, conservation can save substantial amounts of energy, reduce the need for new power plant construction, create thousands of jobs and save the region hundreds of millions of dollars which now leave the region to pay for imported fuels.

Conservation requires some investment in capital improvements, such as more efficient appliances and new heating, ventilating and cooling systems. Moreover, as the study shows, conservation measures such as improved building insulation and better temperature controls in factories and large building complexes usually have payback periods of less than four years. These improvements may cost a large amount of money in the next few years, but as the study concludes, the cost of saving energy will be far cheaper than the cost of importing and producing energy. In addition, many conservation products will be manufactured, installed and maintained by New Englanders. This means jobs and revenue for our region.

The following scenarios are a continuation of the "what if" approach mentioned earlier. Considered are (1) price-induced conservation, (2) commercial conservation, (3) industrial conservation, (4) residential conservation, and (5) comprehensive conservation scenarios.

19.1 Effects of Price-Induced Conservation (PRICCON)

The Price-Induced Conservation simulation estimates the effect of conservation caused by higher energy prices. Estimating the region's response to higher energy prices is done by looking at past responses to energy changes.[6] There is, however, no way to estimate the cost of these

TABLE II

BASIC ECONOMIC PROJECTIONS AND IMPLIED GROWTH RATES - NEW ENGLAND

Variable	1980	1985	1974-1980 Growth Rate[1] (percent)	1980-1985 Growth Rate[2] (percent)
Gross Regional Product (billions of 1974 $)	95.0	113.2	3.5	3.5
U. S. GNP Deflator (1974 = 1)	1.445	1.855	6.14	5.0
Wages (1974 dollars/hour)	6.48	8.97	7.63	6.5
Sector Demand Levels - G&E-M (Net Exports) (in $ millions current)				
Agriculture, Mining, Construction	5054.0	7731.0	9.84	8.5
Manufacturing	6374.0	9749.0	9.84	8.5
Commercial Transportation	618.0	944.0	9.84	8.5
Services	19290.0	29507.0	9.84	8.5
Population (in millions)	12.74	13.26	0.79	0.8
Labor Force (in millions)	6.10	6.12	1.69	1.62
Dwellings (in millions)	4.272	4.581	0.6	0.6
Government and Other Employment (in millions)	1.23	1.35	1.5	1.5
Labor Productivity (1974 = 1)	1.093	1.178	1.5	1.5
Vehicles	8.143	9.228	2.5	2.5

[1] Prepared by Ed Zeitz and John Lutostanski of the Massachusetts Energy Policy Office. Based in part on projections of the Massachusetts Econometric Model, Treyz, et al. (1977)

[2] Growth rates per annum compounded continuously.

TABLE III

Energy Prices to the Manufacturing Sector Used in Projections[1]

(in constant 1974 dollars)

Energy Forms	Units	1974	Basic FEA Projections 1980	1985
Electricity	(¢/kwh)	2.8100	3.144	3.402
Nuclear	(¢/kwh)	0.212	0.212	0.212
Natural Gas	($/mcf)	2.620	2.620	2.620
LPG	($/barrel)	9.068	11.343	12.145
Gasoline	(¢/gallon)	35.23	51.020	55.892
Kerosene	(¢/gallon)	35.961	39.700	43.100
Distillate	(¢/gallon)	32.50	36.943	38.836
Residual	($/barrel)	12.43	14.521	14.685
Coal	($/short ton)	25.15	33.488	35.040
Exotic	($/BTU)	-0-	-0-	-0-

1 - Department of Energy Projection from the PIES Study

TABLE IV

REAL ENERGY PRICE CHANGES FROM 1974 to 1985

FUEL/SECTORS	Manufacturing	Commercial Transportation[1]	Commercial Sector	Residential Transportation[2]	Residential Sector	Electric Utilities
Electric ¢/kwh	.5274	-0-	- .0209	-0-	- .1005	-0-
% Change	18.77	-0-	- .53	-0-	- 2.49	-0-
Natural Gas $/mcf	.3680	-0-	- .2305	-0-	1.3999	1.9879
% Change	14.05	-0-	- 6.83	-0-	59.49	198.77
LPG $/bbl	3.0776	-0-	3.0776	-0-	3.0776	3.0776
% Change	33.94	-0-	33.94	-0-	33.94	33.94
Gasoline ¢/gal	20.6622	18.2737	24.1219	18.2737	-0-	-0-
% Change	58.65	44.49	68.47	44.49	-0-	-0-
Kerosene ¢/gal	8.1387	8.1387	8.1387	-0-	8.1387	8.1387
% Change	23.28	23.28	23.28	-0-	23.28	23.28
Distillate ¢/gal	6.3356	5.3248	6.3194	6.3356	5.8792	8.1278
% Change	19.49	15.69	19.43	19.49	16.52	10.01
Residual $/bbl	2.0767	-0-	.5593	-0-	-0-	1.9069
% Change	16.71	-0-	4.09	-0-	-0-	16.67
Coal $/s.t.	9.8904	-0-	9.8904	-0-	9.8904	5.4403
% Change	39.33	-0-	39.33	-0-	39.33	21.63

1 - Public Transit, buses, trucks, etc.
2 - Private automobiles

TABLE IV(a)

FUEL PRICE INCREASES FROM 1974 to 1985[3]

(Percent increase per annum)

FUEL/SECTORS	Manufacturing	Commercial Transportation	Commercial Sector	Residential Transportation	Residential Sector	Electric Utilities
Electric	1.5758%	-0-	- .0485%	-0-	- .2292%	-0-
Natural Gas	1.2020	-0-	- .6407	-0-	4.3353	10.4619
LPG	2.8921	-0-	2.8921	-0-	2.8921	-0-
Gasoline	4.285	3.4021	4.8559	3.4021	-0-	4.2850
Kerosene	1.9208	1.9208	1.9208	-0-	1.9208	1.9208
Distillate	1.6322	1.3497	1.6276	1.6322	1.3993	.8710
Residual	1.4144	-0-	.3652	-0-	-0-	1.4115
Coal	3.0609	-0-	3.0609	-0-	3.0609	1.7962

3 - (- indicates a decrease in price)

TABLE V: BASECASE COMPARISON - 1974 & 1985[1]

ENERGY USE	MANUFACTURING	COMMERCIAL	RESIDENTIAL	UTILITIES	TOTAL
Electric					
# BTU's more/less (Trillion BTU)	43.078	59.487	49.661	-0-	152.227
% Change in Consumption	63.10%	85.04%	55.78%	-0-	66.99%
Natural Gas					
# BTU's more/less (Trillion BTU)	18.769	41.734	14.705	- 11.748	63.868
%Change in Consumption	41.90%	65.79%	10.32%	- 100.00%	24.22%
Distillate Oil					
# BTU's more/less (Trillion BTU)	28.896	95.461	131.661	1.885	273.564
% Change in Consumption	37.73%	48.39%	35.43%	18.53%	39.11%
Residual Oil					
# BTU's more/less (Trillion BTU)	43.90	130.400	-0-	83.697	257.998
% Change in Consumption	39.45%	59.11%	-0-	18.53%	32.93%
TOTAL					
Trillion BTU	135.076	331.636	204.886	206.249	1016.311
% Change	44.25%	59.15%	32.24%	34.73%	36.32%

1 - See Appendix III

TABLE V(a): BASECASE COMPARISON - 1974 & 1985[1]

ECONOMIC FACTORS	MANUFACTURING	COMMERCIAL	RESIDENTIAL	UTILITIES	TOTAL
Labor					
Additional Person/ years (in millions)	.2457	.5620	-0-	.0080	1.086
% Change	17.62%	26.41%	-0-	41.67%	21.11%
Price/Cost of Living (real price increases)					
% Change	11.99%	7.90%	18.46%	-0-	10.01%
Production					
1974 $ millions	20,477	28,054	-0-	-0-	55,660
% Change	38.72%	49.09%	32.29%	-0-	42.48%
Total Energy Growth Rate	3.387	4.315	2.573	2.747	2.856

[1] - See Appendix III

changes in energy use. Thus the economic effects shown in Tables VI and VI(a) are reductions which could occur at no cost. Whether such reductions would occur at no cost is unclear. However, the price-induced effects are sufficiently small in some sectors to justify that assumption.

Despite its shortcomings, this simulation helps to estimate levels of conservation which might be achieved without government programs.

With price-induced conservation (See Tables IV and IV(a) for rate of price increases) total energy use per unit of production in 1985 is 10.72% less than the base projection.[7] (See Tables VI and VI(a)). Included in this is a substantial decline in gasoline use (down 24%) per vehicle mile and reductions in use of other petroleum products of about 7% to 9% in 1985.[8]

The average real price decreases 1.27% as a result of this energy substitution, and the price of residential transportation declines by 22.09% and 6.82% for other residential energy uses. Conservation implies that the same services are provided with less energy. The price for the commercial sector declines 0.32%, while the price for manufacturing declines 0.59%.

Those price reductions cause increases in production, bringing it 0.44% above the base projection.

19.2 Commercial Conservation (COM F-20, COM F-30, COM 5-30)

For 10% to 30% reductions in energy use, conservation investments in the commercial sector appear to be the cheapest way to cut total energy consumption (Compared to price-induced conservation). It is economically feasible to induce energy use in the commercial sector 20-30% lower than the Base Case levels. To examine this potential, we developed nine simulations, considering three levels of conservation and three cost assumptions. In these, we considered 10,20, and 30% reductions in energy use. One assumption is that conservation is achieved at no additional net cost to the firm

(COM F-20, COM F-30, COM 5-30). The other assumption is that investments achieving a 10% reduction will pay for themselves in two years; a 20% reduction in four years and a 30% reduction in six years. These cost assumptions were indicated by discussions with conservation experts on the average cost of conservation improvements requiring alterations/additions to capital stock. That many easy or no-cost improvements were completed by 1974 is assumed.[9]

As such, these cost estimates are probably somewhat high. Current experience indicates (a) only a small portion of those buildings which could save 15-20% through low- or no-cost operating changes have done so, and (b) improved heating, ventilation and air conditioning controls can save 20-30% in many existing buildings with a 1-3 year payback, (c) new buildings (1978 on) will make up 25-35% of the energy used in the commercial sector and that new mandatory building standards can significantly reduce the energy consumption in these buildings.[10]

Three conservation cost levels were defined, based on two methods of charging improvements to commercial sector prices. Capital investments for conservation are assumed to be added to commercial prices at either a five percent rental rate (our estimate of the real cost of capital), or a 12 percent rental rate -- the internal rate of return on capital achieved by industry in the United States. Several combinations of rental rates and cost assumptions are identical to the above assumptions. Cases "CON F-20", CON F-30" and "CON 5-30" represent the most likely commercial conservation investments.

The adoption of energy-efficient building standards for new

TABLE VI - CASE: PRICE-INDUCED CONSERVATION (PRICCON)

CHANGES FROM BASE

ENERGY USE	INDUSTRIAL	COMMERCIAL	RESIDENTIAL	UTILITIES	TOTAL
Electric					
Trillion BTU	- 7.418	- 7.108	- 11.790	-0-	- 26.316
% Change	- 6.66	- 5.49	- 8.50	-0-	- 6.93
Natural Gas					
Trillion BTU	- 2.033	- 3.432	- 9.366	-0-	- 14.829
% Change	- 3.20	- 3.26	- 5.96	-0-	- 4.53
Distillate Oil					
Trillion BTU	- 4.829	-13.338	- 29.452	- 1.742	- 67.126
% Change	- 4.58	- 4.56	- 5.85	- 14.42	- 6.90
Residual Oil					
Trillion BTU	- 6.852	-16.169	-0-	- 77.211	-100.233
% Change	- 4.42	- 4.61	-0-	- 14.42	- 9.62
TOTAL					
Trillion BTU	-21.472	-41.206	- 53.325	- 86.991	-408.745
% Change	- 4.84	- 4.62	- 6.35	- 10.87	- 10.72

TABLE VI(a) - CASE: PRICE-INDUCED CONSERVATION (PRICCON)

CHANGES FROM BASE

ECONOMIC FACTORS	INDUSTRIAL	COMMERCIAL	RESIDENTIAL	UTILITIES	TOTAL
Labor					
Person-years	6300	13000	-0-	- 1800	19200
% Change	.39	.48	-0-	- 6.62	.44
Price					
% Change	- .59	- .32	- 6.82	-0-	- 1.27
Production					
1974 $ Millions	285.281	410.719	6.692	-0-	822.844
% Change	.39	.48	.21	-0-	.44

TABLE VII - CASE: COMMERCIAL CONSERVATION (COM F-20)

CHANGES FROM BASE CASE

ENERGY USE	MANUFACTURING	SERVICES	RESIDENTIAL	UTILITIES	TOTAL
Electric					
Trillion BTU	- 639.	- 26.135	- 1.803	-0-	- 28.578
% Change	- .57	- 20.19	- 1.30	-0-	- 7.53
Natural Gas					
Trillion BTU	1.352	- 19.037	2.969	-0-	- 14.715
% Change	2.13	- 18.10	1.89	-0-	- 4.49
Distillate Oil					
Trillion BTU	.582	- 56.096	1.333	- 1.892	- 56.039
% Change	.55	- 19.16	.26	- 15.66	- 14.47
Residual Oil					
Trillion BTU	.577	- 67.486	-0-	- 83.847	- 15.757
% Change	.37	- 19.23	-0-	- 15.26	- 14.47
TOTAL					
Trillion BTU	1.924	-172.548	2.563	- 94.467	-262.393
% Change	.43	19.34	.31	11.81	- 6.88

TABLE VII(a) - CASE: COMMERCIAL CONSERVATION (COM F-20)

CHANGES FROM BASE CASE

ECONOMIC FACTORS	MANUFACTURING	SERVICES	RESIDENTIAL	UTILITIES	TOTAL
Labor					
Persons-years	200.	8800.	-0-	-2000.	7200.
% Change	.01	.33	-0-	7.35	.12
Price					
% Change	- .13	- .89	.22	-0-	- .52
Production					
1974 $ Millions	11.312	777.563	-0-	-0-	301.625
% Change	.02	.33	-0-	-0-	.16

buildings by 1980 and no- or low-cost changes in operating procedures could cut consumption by 15 percent in existing buildings. Energy use in the service sector could be reduced by 20 percent at essentially no cost as simulated in "COM F-20". Immediate adoption of building standards, coupled with moderate cost (two-year payback) investments in existing buildings could reduce consumption by 30 percent. (Simulated in COM 5-30 Case).[11] Immediate application of building standards and very low cost changes in operating procedures could reduce commercial energy use by 30 percent at no significant cost to the economy (simulated in "COM F-30"). While the magnitude of the economic benefits vary, under all conceivable cost assumptions, conservation in the commercial sector is of significant benefit to the economy.

19.3 COM F-20

Even the most conservative case, "COM F-20" (Tables VII and VII(a)) indicates significant reductions in energy use and real economic benefits. Total energy use declines nearly seven percent with a particularly significant reduction in demand for residual oil of 14.5%. A 15.7% reduction in utility use of residual oil, caused by a 7.5% decline in electricity demand, accounts for more than half of the reduction. The price decline of 0.9% in the service sector stimulates production and employment, adding $300 million worth of business and creating 7,200 jobs.

19.4 COM 5-30

A somewhat more ambitious case requiring significant investment in existing buildings, "COM 5-30", yields significantly greater reduction in energy use with slight, but positive, changes in the economy (Table VIII and VIII(a)). Total energy use declines 10.5%, with a 22% decline

TABLE VIII - CASE: COMMERCIAL CONSERVATION (COM 5-30)

CHANGES FROM BASE CASE

ENERGY USE	MANUFACTURING	SERVICES	RESIDENTIAL	UTILITIES	TOTAL
Electric					
Trillion BTU	- 1.010	- 39.637	- 2.818	-0-	- 43.465
% Change	- .91	- 30.62	- 2.03	-0-	- 11.45
Natural Gas					
Trillion BTU	2.155	- 29.152	4.736	-0-	- 22.260
% Change	3.39	- 27.72	3.01	-0-	- 6.80
Distillate Oil					
Trillion BTU	.912	- 85.501	2.111	- 2.877	- 85.318
% Change	.87	- 29.21	.42	- 23.82	- 8.77
Residual Oil					
Trillion BTU	.899	- 102.83	-0-	-127.526	-229.456
% Change	.58	- 29.30	-0-	- 23.82	- 22.03
TOTAL					
Trillion BTU	3.039	- 262.667	4.132	-143.677	-399.023
% Change	.69	- 29.44	.49	- 17.96	- 10.46

TABLE VIII(a) - CASE: COMMERCIAL CONSERVATION (COM 5-30)

CHANGES FROM BASE CASE

ECONOMIC FACTORS	MANUFACTURING	SERVICES	RESIDENTIAL	UTILITIES	TOTAL
Labor					
Persons-years	200.	9900.	-0-	-3100.	7300.
% Change	.01	.37	-0-	- 11.40	.12
Price					
% Change	- .13	- .99	.35	-0-	- .57
Production					
1974 $ Millions	11.313	313.375	-0-	-0-	338.875
% Change	.02	.37	-0-	-0-	.18

in residual oil use. Price and production changes are similar to COM F-20.

19.5 COM F-30

The "COM F-30" Case, reflecting immediate application of ASHRAE building standards, and an optimistic view of the potential for energy conservation in existing buildings, achieves the same energy savings as above.[12] However, COM F-30 predicts an even better economic picture (Tables IXand IX(a)). With no substantial investment costs, average prices in the economy fall 0.8%, with a 1.3% decline in service sector prices. Accordingly, production increases are more significant than in the other cases. Total production increases 0.32% or $590 million, led by a $474 million increase in service sector production.

Of the three relevant commercial conservation cases, COM 5-30 stands in the middle - bracketed by COM F-20 with a similar economy, but somewhat greater energy use, and COM F-30 with a similar energy use but an improved economy.

19.6 Industrial Conservation (IND)

Little is known about the conservation cost and potential in the manufacturing sector. "IND" represents the investment costs and conservation potential indicated in the FEA's study of economically achievable conservation measures in ten industry groups. The reductions used are those set as voluntary targets for conservation in 1980 under the Energy Policy and Conservation Act. The required investment will probably be made by 1985. The manufacturing sector reduces energy use 17 percent, reducing total New England energy use by 4 percent. Small improvements occur in the economy. (See Tables X and X(a)).

TABLE IX - CASE: COMMERCIAL CONSERVATION (COM F-30)

CHANGES FROM BASE CASE

ENERGY USE	MANUFACTURING	COMMERCIAL	RESIDENTIAL	UTILITIES	TOTAL
Electric					
Trillion BTU	- .998	- 39.518	- 2.808	-0-	- 43.323
% Change	- .90	- 30.53	- 2.02	-0-	- 11.42
Natural Gas					
Trillion BTU	2.152	- 29.062	4.719	-0-	- 22.18
% Change	3.39	- 27.63	3.00	-0-	6.77
Distillate Oil					
Trillion BTU	.917	- 85.241	2.21	- 2.864	- 85.0
% Change	.87	- 29.12	.42	- 23.74	- 8.74
Residual Oil					
Trillion BTU	.909	- 102.517	-0-	-127.112	-228.720
% Change	.59	- 29.21	-0-	- 23.74	- 21.96
TOTAL					
Trillion BTU	3.063	- 261.874	4.117	-143.210	-397.7
% Change	.69	29.35	.59	- 17.90	- 10.43

TABLE IX(a) - CASE: COMMERCIAL CONSERVATION (COM F-30)

CHANGES FROM BASE CASE

ECONOMIC FACTORS	MANUFACTURING	SERVICES	RESIDENTIAL	UTILITIES	TOTAL
Labor					
Persons-years	1800	15700	-0-	-3100	14400
% Change	.08	.58	-0-	-11.0%	.23
Price					
% Change	- .2	- 1.34	.35	-0-	- .78
Production					
1974 $ Millions	46.80	474.24	-0-	-0-	588.93
% Change	.06	.56	-0-	-0-	.32

TABLE X - CASE: INDUSTRIAL CONSERVATION (IND)

CHANGES FROM BASE CASE

ENERGY USE	MANUFACTURING	SERVICES	RESIDENTIAL	UTILITIES	TOTAL
Electric					
Trillion BTU	- 21.63	- .505	- .722	-0-	- 22.86
% Change	- 19.43	- .39	- .52	-0-	- 6.02
Natural Gas					
Trillion BTU	- 10.397	.820	1.439	-0-	- 8.137
% Change	- 16.36	.78	.92	-0-	- 2.48
Distillate Oil					
Trillion BTU	- 17.647	.124	- .011	- 1.513	- 19.04
% Change	- 16.73	.04	-0-	- 12.53	- 1.96
Residual Oil					
Trillion BTU	- 25.177	.079	-0-	- 66.911	- 92.167
% Change	16.73	.02	-0-	- 12.53	- 8.85
TOTAL					
Trillion BTU	- 76.151	.512	.704	- 75.564	- 150.442
% Change	- 17.17	.06	.08	- 9.44	- 3.94

TABLE X(a) - CASE: INDUSTRIAL CONSERVATION (IND)

CHANGES FROM BASE CASE

ECONOMIC FACTORS	MANUFACTURING	SERVICES	RESIDENTIAL	UTILITIES	TOTAL
Labor					
Person-years	1000.	-1300.	-0-	-1600.	-1800.
% Change	.06	- .05	-0-	- 5.88	- .03
Price					
% Change	- .60	- .05	- .04	-0-	- .22
Production					
% Change	.06	- .05	-0-	-0-	.01

19.7 Residential Conservation (RES 20 and RES 30)

Two levels of conservation improvements are examined in the residential sector. Fortunately, we have very reliable estimates of conservation measures and their costs for this sector.[13] "RES 20" (20% conservation) assumes a minimum attic insulation of R-19, and weather-stripping and storm windows combined, reducing residential energy use by 20 percent, at a cost of $903 million in 1974 dollars. RES 30 (30% conservation) adds R-19 floor insulation to the above measures and saves energy use by 30%. The total cost of the investments required to save 30% is $1,243 million in 1974 dollars. While these costs are not trivial, the economic impacts of these cases are quite significant.

19.8 RES 20

RES 20 reduces total regional energy use by 7 percent as follows: distillate oil is cut 9.5 percent, residual oil 9.4 percent, and electricity 9.0 percent (see Table XI). The money saved on energy costs is spent elsewhere in the economy; as a result, production increases 0.45 percent or by $834 million in 1974 dollars. Nearly 20,000 new jobs are created (see Table XI(a)).

19.9 RES 30

RES 30 reduces total energy use by 10 percent: distillate oil by 13.7 percent, residual oil by 13.4 percent and electricity by 12.7 percent (see Table XII). Again, the energy cost savings are spent elsewhere in the economy; production increases 0.63 percent or $1192 million in 1974 dollars. Nearly 30,000 new jobs are created. (See Table XII(a)).

TABLE XI - CASE: RESIDENTIAL CONSERVATION (RES 20)

CHANGES FROM BASE CASE

ENERGY USE	MANUFACTURING	SERVICES	RESIDENTIAL	UTILITIES	TOTAL
Electric					
Trillion BTU	- .887	- 1.527	- 31.620	-0-	- 34.004
% Change	- .80	- 1.18	- 22.80	-0-	- 8.97
Natural Gas					
Trillion BTU	2.212	2.982	- 30.545	-0-	- 25.349
% Change	3.48	2.84	- 19.44	-0-	- 7.74
Distillate Oil					
Trillion BTU	.565	1.004	- 92.096	- 2.253	- 92.781
% Change	.54	.34	- 18.30	18.65	- 9.54
Residual Oil					
Trillion BTU	.554	.938	-0-	- 99.856	- 98.362
% Change	.36	.27	-0-	- 18.65	- 9.44
TOTAL					
Trillion BTU	2.498	3.399	- 162.403	-112.502	-269.014
% Change	.56	.38	- 19.32	- 14.06	- 7.05

TABLE XI(a) - CASE: RESIDENTIAL CONSERVATION (RES 20)

CHANGES FROM BASE CASE

ECONOMIC FACTORS	MANUFACTURING	SERVICES	RESIDENTIAL	UTILITIES	TOTAL
Labor					
Person-years	6600.	14600.	-0-	- 2300.	19800.
% Change	.39	.37	-0-	- 8.34	.32
Price					
% Change	.04	.03	-20.28	-0-	- .65
Production					
1974 $ Millions	296.055	456.877	9.281	-0-	827.268
% Change	.41	.54	.29	-0-	.45

TABLE XII - CASE: RESIDENTIAL CONSERVATION (RES 30)

CHANGES FROM BASE CASE

ENERGY USE	MANUFACTURING	SERVICES	RESIDENTIAL	UTILITIES	TOTAL
Electric					
Trillion BTU	- 1.304	- 2.237	- 44.637	-0-	- 48.178
% Change	- 1.17	- 1.73	- 32.18	-0-	- 12.70
Natural Gas					
Trillion BTU	3.326	4.477	- 43.491	-0-	- 35.687
% Change	5.23	4.26	- 27.67	-0-	- 10.90
Distillate Oil					
Trillion BTU	.831	1.471	- 132.036	- 3.189	- 132.926
% Change	.79	.50	- 26.23	- 26.50	- 13.66
Residual Oil					
Trillion BTU	.813	1.374	-0-	- 141.353	- 139.165
% Change	.52	.39	-0-	- 26.40	- 13.36
TOTAL					
Trillion BTU	3.743	5.087	- 231.771	- 159.256	- 382.207
% Change	.84	.57	- 27.58	- 19.90	- 10.02

TABLE XII(a) - CASE: RESIDENTIAL CONSERVATION (RES 30)

CHANGES FROM BASE CASE

ECONOMIC FACTORS	MANUFACTURING	SERVICES	RESIDENTIAL	UTILITIES	TOTAL
Labor					
Person-years	9500.	20800.	-0-	- 3200.	28700.
% Change	.58	.78	-0-	- 11.815	.46
Price					
% Change	.06	.04	- 28.86	-0-	- .94
Production					
1974 $ Millions	426.709	658.559	13.378	-0-	1192.413
% Change	.58	.76	.42	-0-	.63

19.10 Comprehensive Conservation (CONT)

The Comprehensive Conservation case (CONT) contains elements of the residential conservation measures considered above. However, we assume more extreme costs for the commercial sector so conservation investments would therefore cost more than twice that assumed for COM 5-30 and COM 12-30. Even with these higher costs, there are still very significant economic benefits.

Total energy use declines 22 percent, or 845.7 trillion BTU's (See Table XIII). There are significant reductions in energy use by manufacturing, services, residences and utilities. Because of a 27 percent decline in electric demand, electric rates increase by 3.6 percent and residual demand decreases by 41 percent.[14] This assumes a Base Case Construction Schedule.

These reductions in the cost of energy lower average real prices by 1.2 percent and stimulate 0.8 percent additional production or $1.47 billion. The increased production also creates 32,000 additional jobs (See Table XIII(a)).

20.0 Alternative Electric Generation Scenarios (Coal, LO NUK, LO NUK C, LO NUK CON)

This portion of the study examines several simulations of various investments in electric generating plants. The methodology used to determine their effect on electric rates and the economy simulates Public Utility Commission decisions on the impact which different investments have on the size of the rate base; then, rates based on the allocation of capital cost, fuel costs, etc (per kWh), and actually used by Public Utility Commissions are determined.

TABLE XIII - CASE: COMPREHENSIVE CONSERVATION (CONT)

CHANGES FROM BASE

ENERGY USE	MANUFACTURING	SERVICES	RESIDENTIAL	UTILITIES	TOTAL
Electric					
Trillion BTU	- 23.492	- 41.693	- 38.906	-0-	- 104.091
% Change	- 21.10	- 32.21	- 28.05	-0-	- 27.43
Natural Gas					
Trillion BTU	- 6.261	- 26.090	- 29.858	-0-	- 62.595
% Change	- 9.85	- 24.81	- 19.00	-0-	- 19.11
Distillate Oil					
Trillion BTU	- 15.832	- 84.067	- 93.551	- 6.891	- 200.946
% Change	- 15.01	- 28.72	- 18.59	- 57.04	- 20.65
Residual Oil					
Trillion BTU	- 23.409	- 101.615	-0-	- 305.403	- 430.428
% Change	- 15.09	- 28.95	-0-	- 57.04	- 41.33
TOTAL					
Trillion BTU	- 70.127	- 259.029	- 171.041	- 344.083	- 845.717
% Change	- 15.81	- 29.03	- 26.35	- 43.00	- 22.17

TABLE XIII(a) - CASE: COMPREHENSIVE CONSERVATION (CONT)

CHANGES FROM BASE

ECONOMIC FACTORS	MANUFACTURING	SERVICES	RESIDENTIAL	UTILITIES	TOTAL
Labor					
Person-years	11400.	26200.	-0-	- 7200.	32300.
% Change	.69	.97	-0-	- 26.47	.52
Price					
% Change	.56	.51	- 21.67	-0-	- 1.19
Production					
1974 $ Millions	510.50	828.815	14.451	-0-	1467.
% Change	.70	.97	.45	-0-	.79

The LOW NUK series eliminates four nuclear plants for three different conservation classes - No Conservation, Price-Induced Conservation, and Stimulated Conservation.

20.1 Coal

The Coal Simulation converts two existing oil-fired facilities to coal, includes the effects of Price-Induced Conservation, and is thus comparable to(PRICCON).Switching to coal increases fuel costs by $108 million, and 0.02¢ per kilowatthour produced (due primarily to increased electric demand and not to increases in the price of the fuel) (see Table XIV(b)). The conversion capital costs decrease the fixed charge per kWh by 5.8 percent or 0.08¢ in 1985. Detailed examination of this simulation indicates a significantly greater reduction in electric rates in 1980 compared with 1985. The difference in rate reduction is due to the substantial amount of electricity generated by nuclear energy in 1985 (keeping in mind that we have assumed six new nuclear facilities as of 1974). Nuclear capacity increases fom 25 percent of total electricity produced in 1980 to 52 percent in 1985. Electric utility coal use including conversion drops by 134.4 trillion Btu's from 1980 to 1985, which amounts to 23 percent of 1980 coal use.

The primary effect of these rate reductions is to stimulate electricity use and reduce costs to the economy (see Tables VI and XIV. Aggregate electricity demand increases in 1985, over the base projection, at these lower rates. A 168 percent increase in demand for coal by 1985 is due to increased electric demand. Since this coal substitutes for more expensive residual oil, utility demand for residual oil declines 2.35 percent (see Table XIV).

TABLE XIV - CASE: COAL*CONVERSION (COAL)

CHANGES FROM BASE CASE

ENERGY USE	MANUFACTURING	SERVICES	RESIDENTIAL	UTILITIES	TOTAL
Electric					
Trillion BTU	-7.036	-7.198	-11.109	-0-	-25.344
% change	-6.32	-5.56	- 8.01	-0-	- 6.68
Natural Gas					
Trillion BTU	-2.039	-3.418	-9.368	-0-	-14.824
% change	-3.21	-3.25	-5.96	-0-	- 4.53
Distillate					
Trillion BTU	-4.834	-13.249	-24.291	-.6778	-66.816
% change	-4.58	- 4.53	- 5.82	-13.89	- 6.87
Residual					
Trillion BTU	-6.828	-16,104	-0-	-152.281	-175.213
% change	-4.40	- 4.59	-0-	-28.44	- 16.82
TOTAL					
Trillion	-21,074	-97.018	-41,091	-108.738	-408.074
% change	- 4.75	-31.38	- 4.61	- 20.83	- 10.70

* COAL includes price conservation

TABLE XIV (a) - CASE: COAL* CONVERSION (COAL)

CHANGES FROM BASE CASE

ECONOMIC FACTORS	MANUFACTURING	SERVICES	RESIDENTIAL	UTILITIES	TOTAL
Labor					
Person-yrs.	1100	1700		-1800	1700
% Change	.07	.06		-6.62	.03
Price					
% Change	.57	.32	-6.53		-1.25
Production					
'74 $ millions	.07	.06	.02		.09
% Change	51.062	52.375	-.534		171.687

* COAL includes price conservation

TABLE XIV (b) - CASE: ELECTRIC COSTS AND REVENUES (COAL)

CHANGES FROM BASE

COSTS	PER UNIT	TOTAL
Fuel	-.1420	-238.4853
% Change	-11.58	- 17.49
Labor	.0000	-33.8804
% Change	.00	- 6.68
Fixed*	.2047	74.9866
% Change	11.06	3.64
Variable**	-.0038	-12.031
% Change	- 1.76	- 5.02
Revenues	-.0038	-209.4092
% Change	- 1.76	- 5.02
Manufacturing	.0599	-50.5225
% Change	1.79	- 4.64
Services	.0701	-57.2832
% Change	1.80	- 3.87
Residential	.0706	-101.6186
% Change	1.80	- 6.36

* Annual payment rate against base case.

** Operation and maintenance costs associated with size of plant

Our results show that coal conversion could clearly be economically beneficial in 1980 and would be a breakeven proposition in 1985.

20.2 LO . NUK

According to the low nuclear simulation (LO NUK), there is a 7.6 percent reduction in the cost of electricity an average of 0.28¢ kWh in 1985. This price reduction is sufficient to stimulate fuel switching in favor of electricity. Demand for electricity increases 2.45 percent while demand for natural gas and distillate oil decreases 1.19 percent and 1.76 percent respectively (see Table XV). Even with increases in electric sales, revenues fall 5.3 percent due to lower rates(see Table XV(b)).

The reduced electric price results in a slightly lower cost of living, down 0.28 percent. Residential energy costs are reduced 3.54 percent (see Table XV(a)). Slight increases in production are stimulated by these price decreases down 0.23 percent in manufacturing and down 0.17 percent in services (see Table XV(a)).

The use of residual fuel by industrial and commercial sectors is reduced by slightly less than 2 percent (see Table XV). However, the electric sector now burns an increased amount of residual oil to substitute for the "missing" nuclear plants. This results in a net increase in residual consumption of 272 percent or 283×10^{12} Btu (utilities burn 292×10^{12} or 46 million barrels more of residual fuel oil). Fuel costs increase accordingly by 42.1 percent per kWh; however, the removal of this major capital investment reduces fixed cost per kWh by 42.2 percent (see Table XV(b)).

TABLE XV - CASE: LOW NUCLEAR BASE (LONUK)

CHANGES FROM BASE

ENERGY USE	MANUFACTURING	SERVICES	RESIDENTIAL	UTILITIES	TOTAL
Electric					
Trillion BTU	1.601	3.586	4.119	-0-	9.307
% Change	1.44	2.77	2.97	-0-	2.45
Natural Gas					
Trillion BTU	- 1.085	- 1.159	- 1.661	-0-	- 3.905
% Change	- 1.71	- 1.10	- 1.06	-0-	- 1.19
Distillate Oil					
Trillion BTU	- 2.887	- 6.203	- 14.669	6.587	-17.161
% Change	- 2.74	- 2.12	- 2.91	54.53	- 1.76
Residual Oil					
Trillion BTU	- 2.924	- 5.805	-0-	291.955	283.226
% Change	- 1.88	- 1.65	-0-	54.53	27.19
TOTAL					
Trillion BTU	- 5.565	- 9.58	- 12.899	238.732	210.727
% Change	- 1.25	- 1.07	- 1.53	29.83	5.52

TABLE XV(a) - CASE: LOW NUCLEAR BASE (LONUK)

CHANGES FROM BASE

ECONOMIC FACTORS	MANUFACTURING	SERVICES	RESIDENTIAL	UTILITIES	TOTAL
Labor					
Person-years	400.	1100.	-0-	700.	2100.
% Change	.02	.04	-0-	2.57	.03
Price					
% Change	- .23	- .17	- 3.54	-0-	- .28
Production					
1974 $ Millions	18.250	32.188	-0-	-0-	54.875
% Change	.02	.04	-0-	-0-	.03

TABLE XV(b) - CASE: ELECTRIC COSTS AND REVENUES

LOW NUCLEAR CONSTRUCTION (LONUK)

CHANGES FROM BASE

COSTS	PER UNIT	TOTAL
Fuel	.5155	620.8628
% Change	42.05	45.53
Labor	.0000	12.4423
% Change	.00	2.45
Fixed*	-.7836	-842.3884
% Change	-42.35	-40.93
Variable**	-.0163	-12.7503
% Change	- 7.59	-5.32
REVENUES	-.2844	-221.8335
% Change	- 7.59	-5.32
Manufacturing	-.2547	-68.8475
% Change	- 7.83	-8.30
Services	-.2980	-74.0979
% Change	- 7.83	-5.07
Residential	-.2999	-78.0898
% Change	- 7.83	-4.89

* Annual payment rate against base case.

** Operation and maintenance costs associated with size of plant.

The effect of the low nuclear simulation on electric rates depends on the price of residual oil. However, under current projections for residual oil prices, reduced nuclear plant construction would lower electric rates. Furthermore, real oil prices would have to be 16 percent higher than are now projected for 1985 to cause an increase in electric prices. Thus, the rate of residual price increases would have to double what is now projected. The energy user taxes proposed in the National Energy Act could result in such higher prices.

20.3 LO NUK C

The LOW NUC C case considered the sensitivity of the above results to price-induced conservation. As expected, reductions in electric demand are more economically beneficial under the low nuclear scenarios. If price-induced conservation occurs in the Base Case, electric rates increase 1.6 percent or 0.05 cents per kWh. In contrast, if such conservation occurs in the low nuclear case, electric rates decrease 8.2 percent or minus 0.31 cent per kWh (see Table XVI(b)). This results in a net decline for the low nuclear case of 0.25 cent per kWh, compared to the Base Case. Obviously, lower electric prices counter the impact of price-induced conservation. Demand does fall in this case; however, compared to the base, it does so only by half as far as projected in NEBASE (see Table XVI). The lower electric rate does reduce revenues by $181 million relative to NEBASE, and by $408 million relative to BASE.

TABLE XVI - CASE: LOW NUCLEAR CONSTRUCTION (LOWNUKC)

CHANGES FROM PRICE INDUCED CONSERVATION (PRICCON)

ENERGY USE	MANUFACTURING	SERVICES	RESIDENTIAL	UTILITIES	TOTAL
Electric					
Trillion BTU	3.071	5.035	5.849	-0-	13.956
% Change	2.96	4.12	4.61	-0-	3.95
Natural Gas					
Trillion BTU	- .515	- .427	- .289	-0-	- 1.229
% Change	- .84	- .42	- .20	-0-	- .39
Distillate Oil					
Trillion BTU	- 1.683	- 3.536	- 9.033	6.895	- 7.350
% Change	- 1.67	- 1.27	- 1.27	66.70	- .81
Residual Oil					
Trillion BTU	- 1.084	- 2.544	-0-	305.592	301.966
% Change	- .73	- .76	-0-	66.70	32.08
TOTAL					
Trillion BTU	- .389	- 1.342	- 3.694	254.097	248.691
% Change	- .09	- .16	- .47	35.63	7.30

TABLE XVI(a) - CASE: LOW NUCLEAR CONSTRUCTION (LOWNUKC)

CHANGES FROM PRICE INDUCED CONSERVATION (PRICCON)

ECONOMIC FACTORS	MANUFACTURING	SERVICES	RESIDENTIAL	UTILITIES	TOTAL
Labor					
Person-years	400.	700.	-0-	1000.	2100.
% Change	.02	.03	-0-	3.95	.03
Price					
% Change	- .17	- .12	- 2.56	-0-	- .21
Production					
1974 $ Millions	13.813	22.938	-0-	-0-	40.625
% Change	.02	.03	.02	-0-	.02

TABLE XVI(b) - CASE: ELECTRIC COSTS AND REVENUES

LOW NUCLEAR CONSTRUCTION WITH CONSERVATION (LOW NUK C)

CHANGES FROM PRICCON

COSTS	PER UNIT	TOTAL
Fuel	.5630	652.4802
% Change	49.20	55.08
Labor	.0000	18.6565
% Change	.00	3.95
Fixed*	-.8585	-842.3884
% Change	-43.18	-40.93
Variable**	-.0180	-10.4405
% Change	- 8.23	-4.81
REVENUES	-.3138	-818.8921
% Change	- 8.24	-4.81
Manufacturing	-.2807	-57.5027
% Change	- 8.28	-5.57
Services	-.3284	-64.0458
% Change	- 8.28	-4.50
Residential	-33.07	-60.1502
% Change	- 8.28	-4.05

* Annual payment rate against base case.

** Operation and maintenance costs associated with size of plant.

While the low nuclear cases do tend to reduce utility revenue, there is also a significant reduction ($842 million) in annual payments to capital. A good portion of these reduced payments are payments to debt (see Table XVI(b)).

20.4 LO NUC CON

The LO NUC CON case projects what would occur if investment in electric generation plant equipment is decreased or replaced by increased investment in conservation. In this scenario, annual payments to electric generating capital are reduced by $842 million while payments to conservation capital, even given the most extreme cost assumptions, are $678.6 million.

As in the Comprehensive Conservation Case, significant reductions in energy use occur in this scenario (see Table XVII). However, the 9.86 percent decline in electric rates results in some fuel substitution, i.e., electricity replacing other fuel (see Tables XVIII and XVIII(a)). Nevertheless, total electric use declines by more than 24 percent from the Base Case (see Table XVII). This decline in electric use reduced residual consumption even though four nuclear plants have been removed.

This reduction in use of electricity does not, however, produce significant declines in the price of electricity. Prices decline only 2.20 percent from the Base Case (see Table XVII(b)).

This case provides substantial economic benefits. Production increases by 0.85 percent, or $1.5 billion, and more than 34,000 jobs are created (see Table XVII(a)).

TABLE XVII - CASE: LOW NUCLEAR CONSTRUCTION WITH CONSERVATION (LONUKCON)

CHANGES FROM BASE

ENERGY USE	MANUFACTURING	SERVICES	RESIDENTIAL	UTILITIES	TOTAL
Electric					
Trillion BTU	- 21.829	- 38.546	- 34.835	-0-	- 92.462
% Change	- 19.60	- 29.78	- 25.12	-0-	- 24.32
Natural Gas					
Trillion BTU	- 7.881	- 27.628	- 32.485	-0-	- 66.959
% Change	- 12.40	- 26.27	- 20.67	-0-	- 20.45
Distillate Oil					
Trillion BTU	- 19.103	- 89.949	- 109.179	- .332	- 213.418
% Change	- 18.11	- 30.73	- 21.69	- 2.75	- 21.93
Residual Oil					
Trillion BTU	- 26.703	- 107.115	-0-	- 14.699	- 136.618
% Change	- 17.21	- 30.52	-0-	- 2.75	- 13.12
TOTAL					
Trillion BTU	- 74.276	- 261.504	- 182.376	- 96.957	- 613.964
% Change	- 16.75	- 29.31	- 21.7	- 12.2	- 16.1

TABLE XVII(a) - CASE: LOW NUCLEAR CONSTRUCTION WITH CONSERVATION (LONUKCON)

CHANGES FROM BASE

ECONOMIC FACTORS	MANUFACTURING	SERVICES	RESIDENTIAL	UTILITIES	TOTAL
Labor					
Person-years	11.800	27.100	-0-	- 6.600	34.400
% Change	.72	1.01	-0-	- 24.46	.55
Price					
% Change	.8	.67	- 25.2	-0-	- 1.48
Production					
1974 $ Millions	530.2	857.0	-0-	-0-	1518.4
% Change	.73	1.0	-0-	-0-	.85

TABLE XVII(b) - CASE ELECTRIC COSTS AND REVENUES

LOW NUCLEAR CONSTRUCTION (LO NUK CON)

CHANGES FROM BASE

COSTS	PER UNIT	TOTAL
Fuel	.3025	-90.0825
% Change	24.67	-6.61
Labor	.0000	-127.2810
% Change	.00	-25.09
Fixed*	-.3913	-842.3884
% Change	-21.15	-40.93
Variable**	-.0054	-64.6192
% Change	- 2.51	-26.97
REVENUES	-.0942	-1124.3711
% Change	- 2.51	-26.97
Manufacturing	-.0733	-232.7581
% Change	- 2.20	-21.37
Services	-.0858	-464.0069
% Change	- 2.20	-31.32
Residential	-.0863	-427.6135
% Change	- 2.20	-26.76

* Annual payment rate against base case.

** Operation and maintenance costs associated with size of plant.

TABLE XVIII - CASE: LOW NUCLEAR CONSTRUCTION

CHANGES FROM COMPREHENSIVE CONSERVATION (CONT)

ENERGY USE	MANUFACTURING	SERVICES	RESIDENTIAL	UTILITIES	TOTAL
Electric					
Trillion BTU	1.664	3.146	4.071	-0-	8.881
% Change	1.89	3.59	4.08	-0-	3.22
Natural Gas					
Trillion BTU	- 1.619	- 1.537	- 2.627	-0-	- 5.784
% Change	- 2.83	- 1.94	- 2.06	-0-	- 2.18
Distillate Oil					
Trillion BTU	- 3.271	- 5.883	-15.628	6.559	- 18.211
% Change	- 3.65	- 2.82	- 3.81	126.40	- 2.36
Residual Oil					
Trillion BTU	- 3.293	- 5.500	-0-	290.704	281.910
% Change	- 2.50	- 2.21	-0-	126.40	46.13
TOTAL					
Trillion BTU	- 6.827	- 9.779	-14.915	237.322	205.844
% Change	- 1.83	- 1.54	- 2.23	52.03	6.93

TABLE XVIII(a)- CASE: LOW NUCLEAR CONSTRUCTION

CHANGES FROM COMPREHENSIVE CONSERVATION (CONT)

ECONOMIC FACTORS	MANUFACTURING	SERVICES	RESIDENTIAL	UTILITIES	TOTAL
Labor					
Person-years	400.	900.	-0-	600.	2100.
% Change	.02	.03	-0-	3.03	.03
Price					
% Change	- .24	- .16	- 4.50	-0-	- .29
Production					
% Change	.03	.03	-0-	-0-	.03

TABLE XVIII(b) - CASE: ELECTRIC COSTS AND REVENUES

LOW NUCLEAR CONSTRUCTION (LO NUK CON)

CHANGES FROM COMPREHENSIVE CONSERVATION (CONT)

COSTS	PER UNIT	TOTAL
Fuel	.7163	617.9627
% Change	88.19	94.27
Labor	.0000	11.8726
% Change	.00	3.22
Fixed*	-1.0908	-842.3884
% Change	-42.78	-40.93
Variable**	-.0288	-12.9627
% Change	- 9.79	-6.90
REVENUES	-.3572	-225.5158
% Change	- 9.80	-6.90
Manufacturing	-.3572	-76.0256
% Change	- 9.86	-8.15
Services	-.4180	-72.2178
% Change	- 9.86	-6.63
Residential	-.4208	-37.1106
% Change	- 9.86	-6.18

* Annual payment rate against base case.

** Operation and maintenance costs assotciated with size of plant.

21.0 Policy Implications

The above simulations contain timely information necessary for energy policy decisions. They clearly demonstrate that energy conservation investments can have distinctly favorable economic impacts for New England. The sensitivity of electric rates to unexpected reductions in electric demand is clear in these cases.

First, energy policy makers can use this report in order to develop a general energy strategy, both for individual states and for the region as a whole. Information in this report can also help to target specific programs, and help provide an estimated cost of those programs. Any decision made must reflect cosideration of (1) the economic impacts of the program,(2) the uncertainty of achieving these benefits, and (3) the sensitivity of the estimated benefits to various assumptions. Conservation should definitely be the first goal of regional energy policy, based on the economic benefits to such a policy as projected in this Report.

The simulations considered in this study reflect New England energy policy as presented in <u>New England Energy Situation and Energy Alternatives for 1985</u>. The simulations indicate positive and, in some cases, significant economic benefits to the region.

The price-induced conservation simulation indicated only small, "free market", adjustments in energy use. However, micro-level studies consistently indicate that most conservation investments are in an individual's economic self-interest. Thus, existing direct market forces are <u>favorable</u> to conservation investments.

Government action is clearly justified in cases where market imperfections mask the long-run benefits of conservation investments, prevent desirable investments, or preclude the individual investor from fully recognizing the benefits of the investment. The last factor is the key for regional policies. The total benefit of energy conservation investments is far greater than the specific value of energy savings to the individual. This is due to the significant increase in regional spending derived from reduced energy expenditures. A large part of this money will remain in the region, creating new jobs and production. The individual investor is often not aware of these indirect benefits when he or she decides to make a conservation investment.

Since market forces favor conservation, strategies to stimulate conservation investments should seek to augment the existing market forces. It is impossible to define precisely the magnitude of government action required to bring about this investment. The major uncertainty lies in forecasting the level of conservation which would occur without government action.

In general, the obstacles to conservation investments include one or more of the following:

1. Inability to predict future energy prices;
2. Inability to predict costs and effectiveness of current and future conservation measures;
3. Inability or unwillingness to use debt for conservation investments, even when return is sufficient to cover debt costs;

4. General uncertainty regarding government energy policies and future energy supplies;

5. A general tendency to avoid capital investment.

General policy devices which could eliminate these obstacles include:

1. Information programs to educate the public and the business community about the value of conservation investments;

2. Mandatory standards requiring investment in minimum levels of energy-efficient capital stock;

3. Financial assistance to improve individual access to financing for energy investments (e.g., loan guarantees, bonding, utility financing);

4. Financial incentives such as tax credits, taxes and sponsored research, to make conservation investments more attractive.

The benefits of energy conservation, aside from economic impacts, such as reduced energy use, do not accrue to the region alone, although they are in the region's long-term interest. The use of financial incentives to encourage energy savings may be justified. However, such policies might also serve to subsidize the benefits to other regions. The use of such financial incentives are probably best left to the federal government. However, regional policy makers should seriously consider financial incentives affecting the use of electricity. There may be benefits to such financial incentives, since the electric supply market is contained within New England.

22.0 Program Benefits - Magnitudes and Uncertainties

Our simulations demonstrate the economic benefits of energy conservation and changes in electric generation investments. The risk of not achieving the economic effects estimated in this study is small. The primary uncertainty in using these results lies in attempting to attribute the specific benefits gained to specific government programs encouraging conservation. The price-induced conservation case - PRICCON - provides some insight into the degree of conservation which increased energy prices might stimulate. However, these reductions are small, on the order of 5%-6% in each major sector. [15]

Nevertheless, the magnitude of benefits from stimulating additional conservation investments demonstrates a significant economic value for the region. Our simulations indicate that there is at least a portion of conservation benefits which could not be attributed to government programs. This information will be applied in more detail to specific cases below.

23.0 Program Recommendations

23.1 Manufacturing

The factors which influence industry's energy conservation investment decisions are not clear. Studies conducted as part of this research indicate that lack of information about the economic potential of such investments is a serious obstacle to conservation. (Appendices III and IV.)

The benefits from industrial conservation are uncertain, and may not be as large as for other sectors. A program designed to provide information and technical assistance to businesses is probably justified.

There are two main reasons that the magnitude of benefits to be derived from this kind of program is relatively small. One, the economic benefits of price-induced conservation are small. Capital cost and availability restrict a large number of investments which might otherwise be considered economical. The price-induced case provides approximately $4 million in yearly benefits regionally. Even if all the firms not now investing in conservation due to "lack of perceived advantage" did invest because of a new program, only 40% of the benefits would be captured -- $1.6 million.[15] Thus, if we assume a 5% real return on the program, a 50% effective program might cost as much as $16 million in 1974 dollars, or $19 million in current (1978) dollars over two to three years.

As the effectiveness of such a program increases, the return increases, to a maximum of 10% for a 100% effective program. We are not judging whether a $19 million program could affect 50% of those firms not investing in conservation now, due to a lack of technical information. This is a judgement for policy makers and program designers. However, if 50% effectiveness can be reached for under $19 million, or if the $19 million program is more than 50% effective, then a relatively risk-free real return of more than 5% seems assured.[16]

The study of wood furniture and metalworking industries (see Appendix II) indicated that many firms are housed in "obsolete" industrial buildings. These structures will need substantial capital investments to make them energy-efficient. It is not clear how long the buildings can remain economically viable to operate. It is certain, however, that rising energy costs will significantly depreciate their value.

23.2 Commercial

Most of the commercial sector's energy use is "building"-related. While capital investment may be necessary in some existing buildings, mary of them can reduce energy use by 15-20% with low-cost changes in operating procedures. Information programs can help in these areas.

However, both for new structures and for existing buildings, energy use standards seem justified. Standards will prevent irresponsible construction and operation of buildings, while information programs will augment market forces.

If price-induced conservation is used as a base line, to compare estimated program benefits, a combination of building standards and information/technical assistance could probably achieve yearly benefits of at least $200 million in 1974 dollars. There is a 20% chance of an additional $280 million in benefits. Total yearly expected benefits are thus $256 million, with expected reductions of 25% in commercial energy use.

The uncertainty lies in what portion of these benefits could be attributed to a conservation program. Estimates of price-induced

conservation probably underestimate the market effects. Other studies estimate reductions of 15% without government programs. This would reduce the yearly benefits of a commercial conservation program to roughly $156 million. Assuming (1) that all of these benefits are derived from the program, (2) a twenty-year "benefit stream", and (3) a 5% real discount rate, a program costing up to $1.944 billion (1979 dollars) is justified.

23.3 Residential

As in other sectors, information programs can play an important role in influencing conservation investments. Standards for new construction can be effective. However, current practice meets proposed new residential standards. Policy makers should give serious consideration to more stringent standards for new construction, particularly given the likelihood of rising energy costs.

The ability to finance energy conservation investments is a serious concern, especially given the age of existing housing stock. Residential conservation cases considered in this study yielded substantial reductions in energy use for the residential sector. The investments necessary for these reductions, however, are primarily aimed at the oldest segments of the housing stock.

Adoption of a financial assistance mechanism to facilitate energy conservation investments is indicated. Banks currently seem reluctant to support conservation in these homes. A financing mechanism need not have significant costs, and could attract additional capital to the region, to support the conservation investments.

A public bonding authority to provide low-cost loans for residential conservation investments seems desirable. While each New England state's debt obligations would be increased, there are substantial benefits to be gained. The yearly beneft, in terms of additional regional product, after reduction for price-induced effects, is $550 million. This is roughly 7.5 times greater than the benefits required for total subsidization of the investment required for 20% reduction in residential energy use. In other words, the present value of these benefits is $6.85 billion, and the estimated cost for insulation and energy retrofit is $903 million. Since even these benefits may be underestimated (income multiplier effects could double the benefits), some financial assistance for residential conservation is desirable.

23.4 Electric Generation

After many years with relatively high electric rates, New England can, with careful planning, achieve relatively low growth in electric rates in 1985. The 1985 time frame, however, severely limits the scope of this study's conclusions regarding electrical generation. Our results do indicate that the construction plans of the utility companies have been historically optimistic, and that even their most recent downward revisions fail to account for likely conservation investments.

As utilities invest in capital intensive modes of electric generation, like nuclear power, electric rates become very sensitive to coordinating construction plans with actual capacity requirements. Ultimately, it is the timing of new facilities which will affect power

rates. This is particularly true toward the late 1980's, when rising oil costs may make it efficient to substitute new electric plants for existing oil-fired facilities. The current regulatory structure does not provide effective public control over construction planning, nor does it permit coordinated energy planning. For example, a particular conservation program might defer the need for a particular plant, while ongoing conservation efforts could reduce the rate of new plant additions.

The low nuclear/conservation (LO NUK CON) case provides an example of the potential effects of substituting conservation investments for investments in nuclear plants. The economic benefits of this case are quite large, and regional products are increased by by $1.5 billion.

No conclusions about current construction plans can be based on this simulation. Current plans for additions of new nuclear facilities are essentially identical to the low nuclear cases. The potential value of accurate forecasting and coordination with conservation programs are clear. This is particularly true since decisions about new generating facilities, required for the late 1980's, are now being made.

APPENDICES PERTAINING TO SECTION I

APPENDIX I

The Direct Impacts of Investments in Outer Continental Shelf Exploration, New Nuclear Plant Construction, New Coal Plant Construction.

Energy Conservation in the Commercial and Residential Sectors -- Potentials and Costs.

Survey of New England Business Attitudes Toward Energy, and Energy Conservation.

APPENDIX II

The Economic Impact of Energy Policies on the Wood Furniture and Metalworking Equipment Industries in New England.

APPENDIX III

Simulation of Energy Scenarios in the New England Macroeconomic Energy Model.

FOOTNOTES

1 Since it was not our objective to develop detailed micro-level estimates for specific cases, the data in some areas may be somewhat outdated.

2 Energy conservation targets established under the Energy Policy and Conservation Act were used. FEA studies established those targets. Cost estimates are based on these studies' definition of economically feasible energy use reductions. Note that these targets are established for 1980 relative to a 1972 base year. There may be greater economically feasible reductions achieved for the 1985 period simulated in this study.

3 The effect of an additional investment in the New England economy have been established to have a Keynsian multiplier effect approaching three.

4 The original PIES supply calculations arrived at this conclusion because it was assumed that oil and gas development would not affect energy prices.

5 This growth rate is higher than the PIES forecast provided by DOE. Total energy growth for that forecast is 2.2% from 1975. However, the PIES forecast includes price-induced conservation not included in the NEME "Base" forecast.

6 Recent NEEPA-estimated elasticities indicate that the variables used in the PRICCON simulation understate price-induced responses.

7 Total energy growth rates from 1974 are 1.8% vs. the 2.2% for the PIES forecast. The lower growth rate for the NEME forecase appears to result from significantly greater reductions in gasoline use. However, as noted in the methodology, sector growth rates for NEME vs. PIES are quite different. PIES projects energy growth rates (from 1975) of: 2.7% residential,

1.3% commercial and 4.3% industrial. NEME growth rates for the PRICCON simulation (from 1974) are: 2% residential, 3.9% commercial, and 2.9% industrial.

8 While gasoline is not examined as a policy scenario, the possible impact of price increases on gasoline was forecasted for the different sectors.

9 Assumptions of Vanderweil Associates and Xnergy, Inc.

10 See Appendix I.

11 COM 5-30 Case probably overestimates the cost of these investments in existing buildings. Old buildings (built before 1978) make up about 75 percent of total commercial energy use in 1985. The cost to the economy of a two-year payback investment for these 75 percent equals a 1.5 year payback for all buildings. Thus, firms are earning a 20 percent rental rate on these investments. (Costs were charged to prices assuming a 6-year payback and five percent cost.) But, in effect, there is a 1.5-year payback, making it a 20 percent rental rate. A five percent rental rate/cost of money for conservation and a 6-year back equals a 20 percent rental rate. Thus, the economic impacts can be achieved even with very competitive payments. If firms were to receive only the average 12 percent return, this simulation would represent cost increases 66 percent higher than estimates of average cost required to save 20 percent. (Both Brookhaven and ADL. See Appendix I.)

12 An Impact Assessment of ASHRAE Standard 90-75, Energy Conservation in New Building Design. ADL, Inc. 1975.

13 Estimates of cost and energy use were made using the "Residential Energy Forecasting Model" (REFORM) on the NEME's computer system. Cost calculations were verified by hand, due to problems uncovered in the REFORM calculations. See Appendix I.

[14] The NEME electric cost model "distributes" electric generating costs to all users. The reduced use base raises the cost of plant charged per kWh.

[15] Total energy use is reduced 10.7% due to significant reductions in transportation energy use.

[16] As indicated in the study, The Economic Impact of Energy Policies on the Wood Furniture and Metalworking Equipment Industries in New England, (Appendix II) sponsored by this office, 55-60% of firms not investing in conservation cited "capital costs" as the reason for this lack of investment. 40% did not invest due to "lack of perceived advantage".

[17] It should be noted that the real interest rate on current state bonds is 3%. Thus, such a program would be a good government "investment".

FINAL REPORT

SECTION II - ENERGY SCENARIO SIMULATIONS

24.0 Overview

In Section I of the NEEPA project, we simulated several conservation and alternative electric generating scenarios in an effort to measure their economic effects on the New England economy. In this section of the project, several new factors are introduced. These are estimates of (1) the effects of capital, labor and energy substitution on energy demand, (2) the cost of borrowing (interest rate) effects, (3) the effects of variation in income on energy demand, (4) coal price effects, (5) weather sensitivity of energy demand in the residential and commercial sectors, and (6) price and demand elasticity of various fuel forms. The effects of these new behavioral estimates on energy simulations similar to those in Section I are then examined. In addition, several new simulations incorporating our estimates of alternative economic growth rates, alternative energy price projections and generating technologies are undertaken.

As you will recall, in Section I we developed the New England Macroeconomic Energy Model (NEME), which was used to examine the consequences of alternative energy supply and macroeconomic demand scenarios for energy demand and economic outcomes in the New

England region. That model is fashioned after the demand-driven Input-Output planning models in the development economics literature. Such models have been used extensively throughout the world, and particularly in developing and socialist countries, to assist in comprehensive economic planning. They are well suited to the examination of marcoeconomic and energy scenarios when designed explicitly for that purpose. Such a model is being utilized in examining national energy policies at Brookhaven National Laboratory. The NEME model was designed with that structure in mind and recognizes the particular problems faced by regional analysts.

The detailed structure of the NEME model has been documented in Section I, Final Report and in Appendix III of this project, with revisions to that structure presented in Appendix IV. Abbott (1978) has discussed the advantages and limitations of this model structure elsewhere. It is important to remind the reader here that the NEME model is based on an Input-Output framework, with aggregate demand set exogenously and with the derived demand for energy and labor determined endogenously from production patterns and input prices. The model is also designed to be flexible, so that the analyst can impose or relax as many assumptions as necessary.

In Section I, the NEME model relied on DOE/PIES behavioral assumptions for the nation as a whole. For example, elasticity assumptions used in Section I are estimates from U.S. rather than regional data and from a period prior to the 1973 energy crisis -- when energy prices were relatively low and price variability was small. As a

result, an assessment of the effects of improved energy price elasticity estimates, and capital, labor, and energy substitution data have either been calculated by study particpants or have been taken from the literature and incorporated into the model. Comparisons of our estimated energy demand elasticities with those used in the DOE/PIES (FEA) model and those of others are set forth in Table 1.

In this section of the report, simulations of the New England economy utilizing the new NEME model are described and compared. Those simulations represent alternative economic and energy scenarios, and so provide a basis for projection of New England's energy needs and their effect on economic outcomes, as well as projections of the consequences of alternative technological and policy options. In these simulations, energy price, technological and macroeconomic demand scenarios are assumed, and the details of energy demand plus certain economic consequences - unemployment, price effects of energy costs, and production and income levels - are projected.

Fifteen simulations, or alternative scenarios, which examine four categories of possibilities, will be described in this report. The first set of simulations will be used to prepare a base projection case. These will include a simple extrapolation of 1974 energy-use patterns to 1980 and 1985, followed by examination of exogenously-forced conservation.[1] The information from these scenarios is then used with new behavior parameters, describing the response of sectoral energy-use patterns to changes in sectoral prices.

In order to investigate the consequences of the behavioral

Table I

Comparisons of Estimated Energy Demand Elasticities with Previous Results *

Sector/Energy Form	Price of:	Estimates SR	Estimates LR	F.E.A.** LR	Baughman et al. *** SR	Baughman et al. *** LR
Residential						
Electricity						
	Electricity	-0.240 (0.034) ++	-1.55	-1.011	-0.187	-1.003
	Distillate	-0.061 (0.032)	-0.393	0.120	0.011	0.046
	Natural Gas	0.009 (0.026)	0.058	0.422	0.045	0.170
	Liquid Gases	0.062 (0.016)	0.400	--	--	--
Distillate						
	Distillate	-0.120 (0.062)	-0.591	-0.515	-1.12	-1.79
	Electricity	-0.001 (0.044)	-0.004	0.116	0.007	0.157
	Natural Gas	0.019 (0.034)	0.082	0.068	0.040	0.185
	Liquid Gases	-0.046 (0.060)	-0.200	--	--	--
Natural Gas						
	Natural Gas	-0.078 (0.047)	-1.418	-0.817	-0.15	-1.009
	Electricity	0.077 (0.033)	1.400	0.316	0.006	0.168
	Distillate	-0.049 (0.055)	-0.891	0.054	0.011	0.055
	Liquid Gases	0.045 (0.045)	0.818	--	--	--
Liquid Gases						
	Liquid Gases	-0.308 (0.179)	-3.347	--	--	--
	Electricity	-0.347 (0.204)	-3.771	--	--	--
	Distillate	1.781 (5.913)	4.200	--	--	--
	Natural Gas	-0.304 (0.133)	3.304	--	--	--
Kerosene						
	Kerosene	-2.442 (5.871)	-5.759	--	--	--
	Electricity	0.275 (0.609)	0.649	--	--	--
	Distillate	1.781 (5.913)	4.200	--	--	--
	Natural Gas	2.253 (0.609)	5.313	--	--	--
	Liquid Gases	-0.818 (0.541)	-1.929	--	--	--

Table I. (continued)

Sector/Energy Form	Price of:	Estimates SR	Estimates LR	F.E.A.** LR	Baughman et al. *** SR	Baughman et al. *** LR
Commercial						
Electricity						
	Electricity	-0.367 (0.068)	1.073	-1.011	-0.187	-1.003
	Residual	0.0036 (0.030)	0.010	0.120	0.011	0.046
	Distillate	0.037 (0.050)	0.108	0.422	0.045	0.170
	Natural Gas	0.164 (0.034)	0.480	--	--	--
Residual						
	Residual	-0.091 (0.229)	-0.502	--	--	--
	Electricity	0.609 (0.415)	3.364	--	--	--
	Distillate	-0.757 (0.455)	-4.182	--	--	--
	Natural Gas	-0.004 (0.273)	-0.022	--	--	--
Distillate						
	Distillate	0.063 (0.114)	1.615	-0.515	-1.12	-1.79
	Electricity	-0.058 (0.078)	-1.487	0.116	0.007	0.157
	Residual	-0.049 (0.060)	-2.410	--	--	--
	Natural Gas	0.057 (0.065)	1.462	--	--	--
Natural Gas						
	Natural Gas	-0.368 (0.091)	-1.614	0.817	-0.15	-1.009
	Electricity	0.088 (0.064)	0.386	0.316	0.006	0.168
	Residual	-0.053 (0.053)	0.232	--	--	--
	Distillate	0.137 (0.095)	0.601	0.054	0.011	0.055

Table I (continued)

Sector/Energy Form	Price of:	Estimates SR	Estimates LR	F.E.A.** LR	Baughman et al.*** SR	Baughman et al.*** LR
Manufacturing						
Electricity						
	Electricity	-0.098 (0.078)	-0.690	-0.330	-0.11	-1.28
	Residual	-0.055 (0.049)	-0.387	0.038	0.01	0.13
	Distillate	-0.153 (0.124)	-1.077	--	--	--
	Natural Gas	-0.012 (0.023)	-0.084	0.136	0.06	0.73
	Liquid Gases	0.162 (0.062)	1.141	--	--	--
Residual						
	Residual	-0.241 (0.394)	-1.746	-1.00	-0.11	-1.32
	Electricity	0.0 ( )	0.0	0.449	0.03	0.34
	Distillate	0.186 (1.202)	1.347	--	--	--
	Natural Gas	0.029 (0.191)	0.210	0.271	0.06	0.75
	Liquid Gases	-0.085 (0.595)	-0.616	--	--	--
Distillate						
	Distillate	-1.470 (0.621)	-6.282	--	--	--
	Electricity	-0.211 (0.275)	-0.902	--	--	--
	Residual	0.380 (0.259)	1.624	--	--	--
	Natural Gas	0.138 (0.108)	0.589	--	--	--
	Liquid Gases	0.384 (0.393)	1.641	--	--	--
Natural Gas						
	Natural Gas	-0.048 (0.102)	-0.089	0.093	-0.07	-0.81
	Electricity	-0.288 (0.267)	-0.538	0.036	0.03	0.34
	Residual	0.180 (0.129)	0.336	0.062	-0.01	0.14
	Distillate	-1.890 (0.0607)	-3.582	--	--	--
	Liquid Gases	-0.0014 (0.775)	-0.0026	--	--	--

Table I (continued)

Sector/Energy Form	Price of:	Estimates		F.E.A.**	Baughman et al.**	
		SR	LR	LR	SR	LR
Manufacturing (cont'd)						
Liquid Gases						
	Liquid Gases	-0.267 (0.293)	2.724	--	--	--
	Electricity	-0.270 (0.312)	-2.755	--	--	--
	Residual	0.211 (0.221)	2.153	--	--	--
	Distillate	-0.755 (0.474)	-7.704	--	--	--
	Natural Gas	0.093 (0.086)	0.949	--	--	--
Kerosene						
	Kerosene	-6.401(11.235)	14.748	--	--	--
	Electricity	2.236 (1.158)	5.152	--	--	--
	Residual	-1.148 (1.059)	2.645	--	--	--
	Distillate	4.856(10.648)	11.188	--	--	--
	Natural Gas	1.495 (0.499)	3.445	--	--	--
	Liquid Gases	0.689 (1.637)	1.094	--	--	--

Table I

* Previous estimates are of U.S. rather than New England parameters. Hence, comparisons of these estimates and previous results constitute a test of the relevance of U.S. parameters in a New England model.

++ Standard errors for the short-run (SR) (one-year) elasticity estimates are reported in parentheses after the estimates.

** Parameters used in the PIES model created by the Federal Energy Administration. These are the basis for the parameters used in the NEME model in Section I.

*** Residential and commercial sectors are aggregated in the estimations of Baughman and Joskow (1975), so that the parameters estimated are identical for those two sectors. Industrial sector parameters are reported in Baughman and Zerhoot (1975).

parameters set forth in Table 1 and Appendix IV, the base projection was also simulated using the parameters and functional form used in the U.S. Department of Energy's PIES model (Project Independence Evaluation System, Documentation), and previously used in NEME. The second category of simulations investigates the consequences of alternative projections of economic conditions and particularly alternative assumptions on aggregate economic growth. These scenarios examine more pessimistic and more optimistic assumptions than those utilized on the base case, as estimated by independent economic forecasters. The third set of simulations examine alternative projections of energy prices to the region. These will measure the New England economy's response to various world energy supply situations as well as the possibility of higher energy prices resulting from government policies.

Higher price scenarios will be simulated using both the new behavioral parameters presented in Appendix IV and the DOE/PIES parameters again to investigate the consequences of these alternative behavioral assumptions. In the final set of simulations, alternative technological assumptions will be imposed on the base projections. These will include investigation of more extensive use of coal by the manufacturing sector, use of solar energy by residential and commercial users, and adoption of cogeneration technologies by manufacturing industries.

The following section of this report examines in more detail the assumptions relevant to each of the scenarios examined. Tables documenting specific inputs to simulations are presented in Appendix V, A. For more detail on the descriptions of the base economy (New England in 1974) from which projections are made, Section I, Appendices 1-3 of the Final Report for this project should be consulted. That section is followed by a discussion of the results obtained for each of the scenarios simulated. That discussion examines the resulting energy demand, economic outcomes, and the important mechanisms which brought about those outcomes. In Appendix V-B, tables reporting the important results obtained for each simulation case are presented.

25.0 Base Case

In the Base case, six simulations are examined: (1) EXTRAP is a simple extrapolation of 1974 energy use patterns to 1980 and 1985 economic activity levels projected independently of the model; (2)-(4) are three conservation simulations (CON20, CON30, and CON30NS)

which are believed to be efficient; (5) a BASE projection is then constructed using behavioral parameters developed in Appendix IV and represents basic projections of economic growth, behavioral response and energy demand in response to DOE-projected energy prices, and (6) FEABS, which is identical to the BASE case with the exception that by using the DOE/PIES model parameters rather than independent behavioral parameters as developed in Section IV, the consequences of alternative energy demand assumptions can be more rigorously evaluated.

25.1 A Simple Extrapolation ("EXTRAP") (Appendix V, A-2)

This simulation holds energy use per unit of output fixed at 1974 levels while economic output and area income continue to expand. National forecasts show that a real per annum growth rate of 3.746% is appropriate for the United States economy for the years 1974 through 1980. Beyond 1980, it is probable that national output will grow at 3.65% per year. Projected New England growth rates are somewhat lower. This slower growth is caused by less population growth and a slower recovery from the past recession.

New England Real:	1974-80 Growth Rate	1980-85 Growth Rate
Disposable Income	3.500%	3.500%
G+E-M (Export demand levels)	3.700%	3.500%
Labor Force	1.689%	1.620%
Wage Rate	1.500%	1.500%

Real export demand grows slightly faster than the rest of output as government demand becomes a larger part of total production. Real income growth is fostered by growth in the labor force and worker productivity. The remainder of the real income growth reduces the unemployment rate or

is soaked up by higher regional prices.

While energy-use patterns will not adjust in response to higher energy prices, some exogenous increase in electricity use is included. Further, it should be noted that the sectoral output mix of final demand will adjust in response to varied sectoral output price increases.

25.2 20% Conservation ("CON20") Appendix V, A-3)

The hidden capacity for energy conservation and the associated increase in capital costs have been the focus of numerous engineering studies -- it is possible to reduce energy demand if the capital stock is upgraded. The "conservation" scenario incorporates Massachusetts Energy Office estimates of conservation and annualized capital costs. In essence, it states that many conservation investments which could achieve quick paybacks are available. Here, these investments are undertaken and the costs are levelized over the life of the capital equipment -- which is exceedingly long. It is believed that cost reductions will foster economic expansion.

In the commercial sector, it is assumed that an investment achieving a 10% reduction in energy demand could pay itself back in 2 years; further investment made to achieve 20% reduction could pay itself back in 4 years. These assumptions embody the belief that some "easy" or costless reductions in energy demand were already achieved by 1974. In this scenario, the commercial sector will achieve a 20% reduction in energy demand by 1985. The total cost of this conservation is approximately $1.7 billion in 1974 dollars. Payments to capital for this sector will be increased to allow an annual 5% real return (after taxes) on this investment.

Less is known about the increased capital costs associated

with industrial energy conservation. In this scenario, the industrial sector is to achieve a 16% energy demand reduction by 1985. It is assumed that this is achieved with investments that on the average could pay themselves back in 5 years. This represents an investment of $1.33 billion (1974 dollars). Payments to capital for this sector will be increased to allow an annual 5.2% real return (after taxes) on this investment

In the residential sector, a 20% reduction in energy demand is to be achieved by 1985. The total capital cost is estimated to be $0.9 billion (1974 dollars). Residential savings in fuel costs, in this model, will in effect increase the consumers' demand for all forms of real output. Of course, part of the increased industrial and commercial output will take the form of conservation materials and services.

Price-induced conservation in the transportation sectors has been included exogenously in this simulation. This will insure that demand will not inordinately shift to the manufacturing and commercial sectors, as it would if there were conservation only in those sectors.

25.3 30% Conservation -("CON 30") (Appendix V , A-4)

Similarly, in this simulation, more conservation investments which could achieve longer paybacks are undertaken. These higher investment costs are levelized over the extremely long life of the capital equipment. It is believed that cost reductions will be passed along to the consumer and foster economic expansion. Again, Massachusetts Energy Office estimates of capital costs are incorporated.

For the commercial sector, 30% reduction in energy demand

will be achieved by 1985. The investment needed to bring conservation from 20% to 30% could achieve a 6-year payback. This represents another $1.7 billion (1974 dollars) investment. This additional investment earns an annual 10% real return (after taxes).

In the industrial sector, a 20% reduction in energy demand will be achieved by 1985. The investment needed to bring conservation from 16% to 20% could achieve a 5.3-year payback. This represents another 0.35 billion (1974) dollar) investment. This additional investment earns an annual 10% real return (after taxes).

Residential energy demand will achieve a 30% reduction by 1985. The increased savings in residential fuel costs will increase the demand for all forms of real output. A greater part of the increased industrial and commercial output will take the form of conservation materials and services.

What would ordinarily be price-induced conservation in the transportation sector has been included exogenously in this simulation, as well.

25.4 30% Conservation: No Seabrook - ("CON30NS")(Appendix V, A-5)

The conservation and capital cost assumptions of the previous simulation are maintained. However, dwindling electricity demand as a result of heavy conservation efforts has made the planned addition of one nuclear plant seem unnecessary. This base capacity and its capital charge are eliminated in this simulation. The changes are outlined in Appendix V, A-1 and A-5.

25.5 Base Case ("BASE") (Appendix V, A-6)

The macroeconomic growth projections of the extrapolations and the conservation scenarios are still maintained. However, the only exogenously specified conservation corresponds to the federally mandated increase in the fuel efficiency of the residential transportation fleet. All other energy-use adjustments (and additional adjustments in residential transportation) are price-induced. This simulation outlines the response that might be expected from "normal behavioral parameters".

This simulation uses the price-elasticity and lagged response mechanisms estimated by the authors (Abbott and Lutostanski, 1978) for use in this model for manufacturing, services, and residential energy services. Energy use of each fuel by each of those sectors separately responds to changes in the price of that fuel and the price of available substitutes. Transportation models utilized DOE/PIES parameters.

As before, the price of electricity is endogenously determined, Seabrook is included in the 1985 base capacity, and the "BASIC" price projections for fuels (as outlined in Appendix V, A-1) are used.

Further, the estimates of the capital costs of conservation (as outlined in the conservation runs) are automatically included. For example, should the commercial sector happen to achieve a 20% reduction in overall energy demand by 1985, capital income to that sector will expand to previously specified levels. If it achieves only part of that conservation, capital income will increase to cover only that partial investment.

25.6 FEA Base Case - ("FEABS")(Appendix V, A-7)

The only differences between the BASE simulation and this

one occur as a result of using a different mechanism to adjust energy use to prices. This simulation uses the "two-step" model of energy demand determination (DOE/PIES), its own price elasticities, its own lagged adjustment mechanism, and its greater time trend in electricity use. The basic macroeconomic and energy price projections are maintained.

26.0 Alternative Economic Growth Projections

Two alternative assumptions on the likely economic future of the New England region are considered in this case. The simulation scenario named HIGRO assumes that real growth in gross regional product will be 3.95% per year to 1980 and 3.35% per year from 1980 to 1985, in place of the assumptions used in both EXTRAP and BASE that GRP will increase at 3.5% per year from 1974 to 1985. The LOGRO scenario assumes that growth in real GRP is 3.33% per year to 1980 and 2.97% per year from 1980 to 1985.

26.1 High Economic Growth - ("HIGRO")(Appendix V, A-8)

More optimistic economic growth is foreseen through 1980 in this version of the macroeconomic inputs. Real growth for New England increases through 1980, then slacks off through 1985. Still, real area income is substantially (2%) higher in 1985 than in the base case.

For each one percent change in the growth rate in area income, roughly one-third corresponds to a change in productivity, another third to a change in the labor force, and the remaining third to a change in the unemployment situation.

New England Real:	1974-80 Growth Rate	1980-85 Growth Rate
Disposable Income	4.070%	3.210%
G+E-M (Export demand levels)	4.270	3.210
Labor Force	1.812	1.552
Wage Rate	1.690	1.403

The "two-step" model of energy demand is not used in this run; instead, the direct elasticity formulation and the newly estimated NEME parameters control energy-use adjustment (as in BASE, not FEABS). The only change in real energy prices (compared to BASE) will occur endogenously in the electric sector.

26.2 Low Economic Growth ("LOGRO") (Appendix V, A-9)

Again, the Abbott-Lutostanski parameters control energy-use adjustment; and the only change in real energy prices will be produced endogenously in the electric sector. The exogenous macroeconomic inputs are more pessimistic. Regional economic growth is slowed only slightly through 1980, but then drops off markedly through 1985. By 1985, real area income has been reduced 3.5% below the base projections.

New England Real:	1974-80 Growth Rate	1980-85 Growth Rate
Disposable Income (GRP)	3.452%	2.830
G+E-M (Export demand levels)	3.652	2.830
Labor Force	1.675	1.407
Wage Rate	1.484	1.277

27.0 Alternative Price Projections

Among the weakest assumptions used in our projections are the energy price estimates. Furthermore, these prices may be altered through public policy initiatives. Hence, simulations

assuming different energy price projections are of considerable interest. Four such simulations are considered here: one assumed higher energy prices (HIPRI), another lower energy prices (LOPRI), the third assumes a "crisis scenario", where the lower prices prevail in 1980, but the higher prices occur in 1985 (HIPLOP), and the fourth examines the high price scenario, using the DOE/PIES behavioral assumptions (FEAHP).

27.1 High Energy Prices ("HIPRI") (Appendix V, A-10 or A-1)

As world energy prices tighten, world oil prices (and the prices of fossil fuel substitutes) might increase dramatically in real terms. This computer simulation will outline the changes in energy use that could be expected to occur in response to these higher real energy prices. In this simulation, the higher fuel prices of Appendix A-1 are used while the basic macroeconomic real growth patterns are reinstituted.

Costs to the electric sector are increased in more than one manner. First, the prices paid for oil and coal increase substantially. Second, the price of nuclear fuel increases to a nominal 1985 level of 1.5¢/kWh (the base case 1985 nominal price was 0.916¢/kWh). And finally, whereas in the basic calculations the 1985 nominal price of newly constructed nuclear plant capacity (exclusive of transmission and distribution equipment) was $1135/kW, this cost is increased to $2270/kW. Similarly, the nominal 1985 cost of new transmission equipment for this nuclear plant has been increased from $834.75/kW to $1169.50/kW.

It is the judgement of the Massachusetts Energy Office that these energy prices and capital costs constitute a reasonable upper realm for New England. This implies that the price-induced conservation that is achieved under these circumstances is the limit to what one might expect given normal adjustement patterns.

27.2 FEA High Price ("FEAHP") (Appendix V, A-10 or A-1)

The same high energy prices and increased electric sector capital costs are maintained. Macroeconomic activity in the region is anticipated to grow at the basic rates. However, the "two-step" energy demand model (DOE/PIES) now gives its estimate of the price-induced changes in energy demand. This is the second and last instance in which this energy demand model is used.

27.3 High Price, Low Path ("HIPLOP") (Appendix V, A-10 or A-1)

In this case, energy prices and nuclear plant capital costs reach their high 1985 levels as previously outlined, but a deceptively low path is followed. Real energy prices remain constant at 1978 levels through 1980. This means that the "low" prices are used for 1980 and the "high" prices are used for 1985 (see Appendix V, A-1).

If it is wondered whether temporarily low energy prices can lull the economy into inactivity and thus cause more economic disruption than would steadily increasing real energy prices, then the results of this simulation should be compared to "HIPRI".

27.4 Low Energy Prices ("LOPRI") (Appendix V, A-10 or A-1)

What would be the energy use pattern in 1985 if real energy prices remained constant at 1978 levels through 1980, and then

rolled slightly back to 1974 levels? The energy-use pattern fostered by the adjustment to lower real prices probably exhibits greater oil dependence while economic growth is undoubtedly improved.

This scenario keynotes the disruptive economic effects of rising real energy prices in New England.

28.0 Alternative Technologies

Recent events in energy markets have also brought attention to new technological alternatives which could enhance energy conservation in New England, or reduce dependence on petroleum as an energy source. Three such alternatives are cogeneration of electricity by the manufacturing and service sectors, modeled in the simulation labeled COGEN; additional use of coal by the manufacturing sector, called COAL; and the use of solar energy for space and water heating by both residential users and the service sector, called SOLAR. For each of these cases, energy uses have been altered to reflect the potential utilization of these options with other energy uses per unit, frozen at projected BASE levels. Simulation results will be used to examine the potential energy demand and economic effects of adoption of these technologies. Since it is unlikely that any of these alternatives will be adopted to a great degree by 1980, only simulation results for 1985 have been produced.

28.1 Cogeneration ("COGEN") (Appendix V, A-11)

In this simulation, the manufacturing and commercial services sectors install 1679 megawatts of electricity-generating equipment by 1985. With this electric equipment on-site, transmission

losses are reduced and the steam by-product can also be better utilized. The manufacturing sector will generate 34.06 trillion Btu's of electricity using this technology. Half of this electricity can be used directly on-site; the other half must be resold to the electric utility for redistribution. The commercial services sector will generate only 6.06 trillion Btu's of electricity using this technology; 60% of this must be sold to the electric utility for redistribution.

A more detailed description of the equipment is given in Appendix V, A-11.

It is assumed that 10% of the electricity which is returned to the utility will be lost in transmission and distribution before it is resold. Transmission losses for other forms of electricity production are already implicit in load factors or input-output coefficients in the model. Since this cogenerated electricity which is returned must use the utility distribution equipment, it must be priced so that both the utility and the cogenerator may idle utility-owned generators and make utility conversion to coal seem less urgent. This less extensive coal use is embodied in the simulation. Keeping this in mind, it was estimated that the utility would repurchase the electricity from the cogenerator at roughly 50% of its usual electricity prices to such a user.

For the cogenerators, this new capital equipment is estimated to cost \$350/kW at 1978 prices, or \$500/kW at 1985 prices. The cost of usual boiler equipment is so much lower that no salvage

value was assumed. These capital costs are to be repaid at an 18% annual nominal rate (after taxes). Comparing these annualized capital costs to the proceeds from repurchased electricity, the manufacturing sector experiences a 1985 saving of $5.30 million (1985) dollars, while the commercial sector saves $10.6 million (1985) dollars. However, these "savings" do not take into account the cost of the increase in oil use, nor the reduction in on-site electricity purchases. This "saving" merely indicates that capital costs can be covered by the proceeds from utility repurchase of electricity.

28.2 Industrial Use of Coal ("COAL")(Appendix V, p.41)

Before the imposition of higher standards for air quality, the industrial sector in New England burned coal as a major form of fossil fuel energy. This scenario examines the return to coal consumption levels of the mid-1960's.

	Distillate	Natural Gas	Residual	Kerosene	Coal	Coal as % of Total
1960	11.8	23.0	150.0	10.0	65.8	25.2
1962	10.8	25.3	161.0	9.4	57.9	21.9
1964	10.3	32.9	186.1	6.9	33.8	12.5
1966	15.9	42.8	149.0	5.9	24.3	10.2
1967	13.5	40.6	154.0	5.7	29.1	12.0

This conversion to coal is not cost-free; substantial nuisance and scrubbing costs may be involved. The nominal price of a short ton of coal in 1985 provided to the manufacturer was raised to $81.69 in order to reflect these higher costs (the base

case price was \$65.00 and the high price was \$83.98). It is assumed that the greater use of coal means returning to burning 30 trillion Btu's in the year 1985. Whatever increase in coal use this means over the BASE projection, those Btu's will be removed proportionately from natural gas and residual use in the manufacturing sector.

28.3 Solar Heating ("SOLAR") (Appendix V, A-12)

Data for this simulation were provided by the Solar Action Office of the Commonwealth of Massachusetts. Passive solar systems are to be incorporated to reduce space-heating demands for the commercial services and residential sectors. These passive solar systems are to be designed into new construction and are assumed to have little cost. Hot water heating, on the other hand, has an associated capital cost of \$2500 (1978 dollars) for a system that reduced annual energy demand by 11 million Btu's. These capital costs are repaid at an 8% annual nominal rate in the residential sector and at a 10% annual nominal rate in the commercial sector.

Reductions in energy demand for hot water heating are assumed to be savings in electricity use. Reductions in demand for space heating are shaved in proportion to Base Case use of electricity, distillate, and residual (see Appendix A-12).

29.0 Conclusions and Policy Implications

The preceding simulations of the New England economy and its likely energy use have provided a number of insights into the

problems with, and potential for, energy policy in the region. In addition, they provide a strong basis for projecting New England's energy requirements in 1980 and 1985.

29.1 Base Projections

The basic projections suggest that energy demand in New England will increase at 1.55% annual growth from 1980 to 1985. Electricity demand will grow at a rate of 3.13% annually to 1980, and 2.74% annually from 1980 to 1985. On the other hand, petroleum (excluding gasoline) demand will increase 1.2% per year to 1980 and about 0.7% per year from 1980 to 1985. These growth rates reflect approximately 20% conservation in transportation, 10% conservation by the manufacturing sector, and 3% conservation for services and residential energy demand in 1985 over per-unit energy uses in 1974. The higher energy prices assumed for these projections bring about the observed conservation, but they also cause total energy costs, and hence real sectoral prices, to rise 0.5% by 1980 and 0.6% by 1985. However, even with this conservation, <u>real</u> energy costs per unit of <u>real</u> production rise 3.2% by 1980 and 2.1% by 1985. Moreover, the <u>real</u> price indicies (inclusive of higher labor costs) rise 4.7% by 1980 and 8.6% by 1985.

29.2 Alternative Economic Projections

Examination of alternative economic projections also suggested that alternative projections can lead to somewhat different energy demands. Our results indicate that for every one percent increase in projected Gross Regional Product, energy demand will increase by about 0.5%. Increases in petroleum and electricity demand are slightly greater than that figure. This result is

largely due to the fact that income elasticities of demand for residential energy use are relatively low, so that the growth in residential transportation and residential energy services is less than that of overall economic growth.

We also found that the choice of model specification of energy demand behavior can substantially alter projections. The behavioral parameters estimated in Appendix IV of this project yield considerably more optimistic projection than do the parameters of the DOE/PIES "two-step" model. In addition, the unexpectely high energy costs resulting from the DOE/PIES parameters are additional evidence that our regional parameter estimates, and particularly our projections of exogenous electricity demand increases, are a more reasonable approximation of New England behaviors.

29.3 Conservation

The conservation simulations suggest that apparent technological opportunities exist to obtain substantially greater levels of energy conservation. They indicate that technologically feasible and economically efficient measures can reduce energy demand to a level 15.3% below our basic projections by 1985. Petroleum demand could be reduced by about 15%, as well. Such conservation would also be of substantial benefit to the economy. Sectoral prices could be as much as 1.4% lower by 1985, with unemployment rates up to 0.67% lower. These come about as a result

of the real cost savings due to energy conservation.

Unfortunately, higher energy prices which are within a reasonable upper limit are unlikely to elicit this conservation. The price scenarios examined, including one with quite high energy prices, yield energy savings of no more than 8.6%, in total, by 1985. This raises two questions which remain to be addressed. The first is, how can the technological opportunities which appear to exist be encouraged by policy? Price signals which reflect the real scarcity of energy are an important means of achieving an efficient allocation of this resource, but there appear to be latent opportunities for conservation which will not be fully exploited. Raising energy prices above the marginal cost of supply in order to further induce conservation imposes a high economic cost. Some other means of tapping this latent conservation potential should be investigated. The second question is, are the cost assumptions of these technological opportunities realistic? Any time such apparently profitable conservation opportunities are rejected by economic actors, one should ask himself if some hidden costs might have been neglected in developing the conservation estimates. Our simulation results suggest, however, that pursuing these conservation opportunities may be the best opportunity for regional energy policy makers.

29.4 Alternative Energy Price Projections

The alternative price scenarios also indicate that higher energy prices impose a substantial economic cost to the New England region. Since virtually all primary energy sources are imported, higher energy prices raise real costs to the region without imparting any increase in

regional incomes. If higher energy prices are the result of federal policies to induce conservation and reduce dependence on foreign oil, these economic costs must be weighed against the benefit of energy conservation achieved. Ways of bringing about that conservation which avoid excessive price increases, or which use taxes whose proceeds remain within the New England region are clearly superior. Those higher energy prices may also be intended to prepare the regional economy for an impending "crisis" of sudden and substantial price increases, but the economic benefit of such preparations which are price-induced are small in the medium- to long-run, especially when compared to the costs of higher energy prices. That is <u>not</u> to say that energy conservation as a preparation for such a crisis is undesirable, but rather that price signals alone are not a completely effective means of eliciting such preparations.

29.5 Alternative Technologies

Technological options, including increased utilization of solar energy, increased coal usage by the manufacturing sector, and cogeneration of electricity and useful "waste heat" were also explored. These options had little macroeconomic impact, but could bring about net energy savings. Additional solar use could reduce regional petroleum demand by 1.65%, and additional coal use could substitute coal for 0.9% of that demand. The cogeneration alternative, according to current assumptions, would reduce coal utilization by the region through reduced electricity demand, and would make conversion of two coal-fired electric generating plants unnecessary. A more reasonable alternative than our current

assumptions for cogeneration might be the elimination of one planned nuclear power plant, rather than idling residual-fired capacity and foregoing coal conversion; but that is if cogeneration activities are implemented. A question which remains is how these relatively marginal economic ventures could be encouraged, so that the obtainable energy savings could be achieved.

The simulation results and our work in preparing inputs highlighted the importance of planning in the electric sector, as well. Both planning and bringing on-line sufficient capacity without providing excessive capacity, and properly controlling costs, are important issues. What happens in other sectors of the economy can significantly impact electricity prices and demand, so coordinated planning is desirable. This is probably another area in which regional energy policy makers should be involved.

The details of the individual simulations suggest a number of other interesting problems and issues. The most significant result of this work, however, is that policies which only depend on energy price manipulations are less likely to be productive than policies which also affect energy conservation behavior directly. Further, the microeconomics of technological and energy conservation alternatives deserve further careful examination, as many questions are raised when one examines the consequences of our current assumptions.

FOOTNOTES

[1] Scenarios examining exogenously forced conservation assume conservation levels believed to be possible technologically, without concern for how adoption of the required conservation measures would occur. It is unlikely that such measures would be adopted without government encouragement or higher energy prices. The base projection case examines how much of such conservation is likely to occur, given assumptions about likely energy price increases and user responses.

[2] Formats for the tables generated by computer simulation of the NEME model are extensively described in the Task I final report of this project. (Appendix III.)

[3] There are additional costs associated with coal utilization that are not incurred in the use of other fossil fuels. Examples are storage costs, costs of railway sidings, handling costs, and waste disposal.

[4] The assumption of fixed nominal aggregate demand is typical of planning models, and is responsible given the issues to be addressed here. It should be noted, however, that the effect on aggregate demand changes in import costs and demand for energy-related equipment is a debatable issue. Resolution of that issue is dependent upon the theoretical macroeconomic framework assumed and particularly changes in government fiscal and monetary policies in response to changes in observed unemployment and inflation outcomes. Our assumptions represent a neutral government response.

Glossary

ASHRAE

An advisory set of building code regulations forwarded by the American Society of Heating, Refrigeration and Air Conditioning Engineers which promote greater insulation and reduced energy consumption.

BTU British Thermal Unit

A standard unit of heat energy: the amount of heat needed to raise the temperature of one pound of water by one degree Fahrenheit.

Capital -Capital Stock

The designation applied to all goods used in the production of other goods, including plants and machinery.

Capital Efficiency (in use of energy)

The degree to which any piece of machinery minimizes the waste of energy. If two pieces of machinery can perform the same amount of useful work, the one which uses less energy is more efficient.

Coefficient

In an equation or numerical relationship, the number that scales the change in the size of one quantity to the change in the size of another.

Example: $Y = 2X$. If X increases by one unit, Y increases by two units. 2 is the coefficient of X in this equation.

Complements - (Complementarity)

Products or commodities so related that a change in the consumption of one will be accompanied by a similar change in the consumption of the other. For example, if tea and lemons are complements, a decline in the price of tea will increase the consumption of tea and the consumption of lemons. The degree of this relationship may be measured by the coefficient of cross-price elasticity.

Cross Price Elasticity

A measure of the degree to which the change in the price of one commodity (say, tea) affects the consumption of another commodity (say, lemons). This is typically expressed as:

A measure of the degree to which the change in the price of one commodity (say, tea) affects the consumption of another commodity (say, lemons). This is typically expressed as:

$$\text{Coefficient Cross-Price Elasticity} = \frac{\text{Percentage change in consumpion of lemons}}{\text{Percentage change in price of tea}}$$

If the two commodities are complements, the sign of the cross-price elasticity is negative. If the two commodities are substitutes, the sign of the cross-price elasticity is positive.

Direct Energy Use

The energy used directly in performing some act of production. If it would require 100 kWh of electricity to press steel into ashtrays, direct energy use would account the 100 kWh of electricity and not the oil used to produce that electricity nor the energy used to refine the steel.

DOE/PIES

The U.S. Department of Energy's Project Independence Evaluation of energy in the United States.

Gross Regional Product (GRP)

A regional version of Gross National Product or GNP. Gross Regional Product is the value of all final sales of goods and services produced within the region in a specific year.

Income Multiplier Effect

The magnified impact that changes in investment or government spending have on total income. The money spent in building a new plant, for instance, sets off a chain reaction. It increases the incomes of the workers directly engaged in the construction, the incomes of the merchants with whom the workers trade, the incomes of the merchants' suppliers, and so on. The dollars do not multiply indefinitely, however, for people do not ordinarily spend all their new income; instead, they spend part and save part. Further, in a regional analysis, some of the income is spent on goods produced outside of the region.

Lagged Adjustment Mechanism Lag Structure

A mathematical modelling technique used to simulate change in energy use that will occur in response to a change in energy prices. The response will not occur all at once; instead, energy use responds slowly, and finally approaches some new "adjusted" level.

NEME

The New England Macroeconomic Energy Model. This is the computer-based model of the New England economy developed by Phillip Abbott for the Massachusetts Energy Office.

Nominal Cost Current Dollars

The cost that would be paid at the time of the transaction using the (inflated) dollars of that moment.

Opportunity Cost

The value of the productive resources that is foregone when these resources are put to use in a specific production process. The economy cannot produce all of its wants. To use steel in the production of airplanes, that steel cannot be used in the production of toasters. The value of the foregone toaster (or the part attributed to the steel) is the opportunity cost of using the steel in the airplane.

Own-Price Elasticity

A measure of the degree to which the change in the price of a commodity affects the consumption of that same commodity. This is typically expressed as:

$$\text{Coefficient of Own-Price Elasticity} = \frac{\text{Percentage change in consumption of tea}}{\text{Percentage change in price of tea}}$$

Price-Induced Conservation

The conservation that is achieved when people and businesses react to higher real market prices of energy (WITHOUT DIRECT GOVERNMENT INTERFERENCE, SUCH AS FORCED INSULATION OR MANDATED FUEL EFFICIENCIES FOR AUTOMOBILES).

Real Cost -- Constant Dollars

The cost of a good in dollars of fixed purchasing power.

REFORM

The New England Regional Commission's "Residential Energy Forecasting Model".

Substitution

Products or commodities so related that a change in the consumption of one commodity (say, coffee) will be accompanied by an opposite change in the consumption of another commodity (say, tea). The degree of this relationship may be measured by the coefficient of cross-price elasticity.